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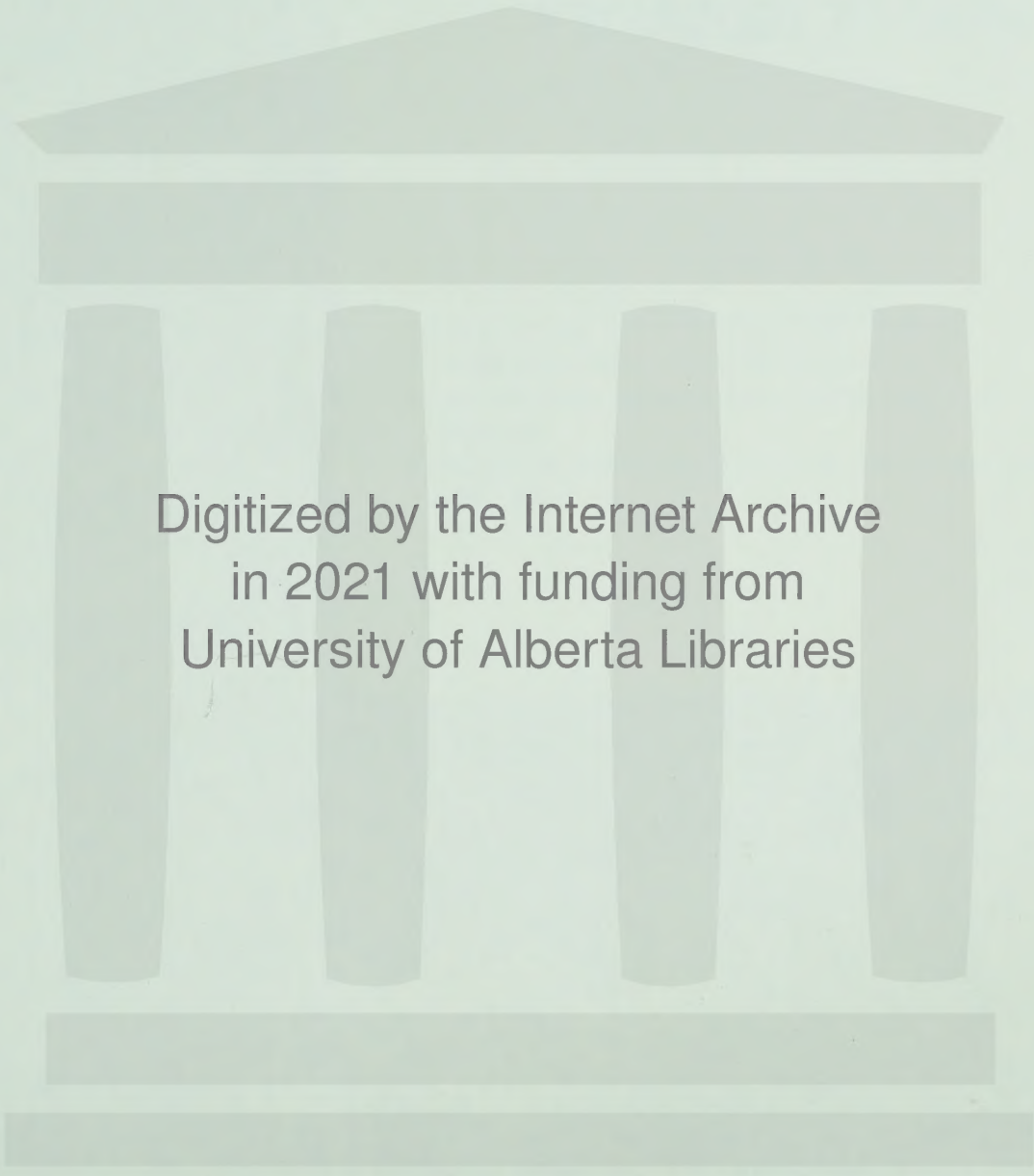
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SCIENCE... A PROCESS APPROACH II

MODULE

1

Observing/a

Perception of Color

OBJECTIVES

At the end of this module the child should be able to

1. *NAME* these colors: yellow, red, and blue.
2. *IDENTIFY* the following colors: yellow, orange, red, purple, blue, and green.
3. *IDENTIFY* other colors as being like one of these colors: yellow, red, or blue.

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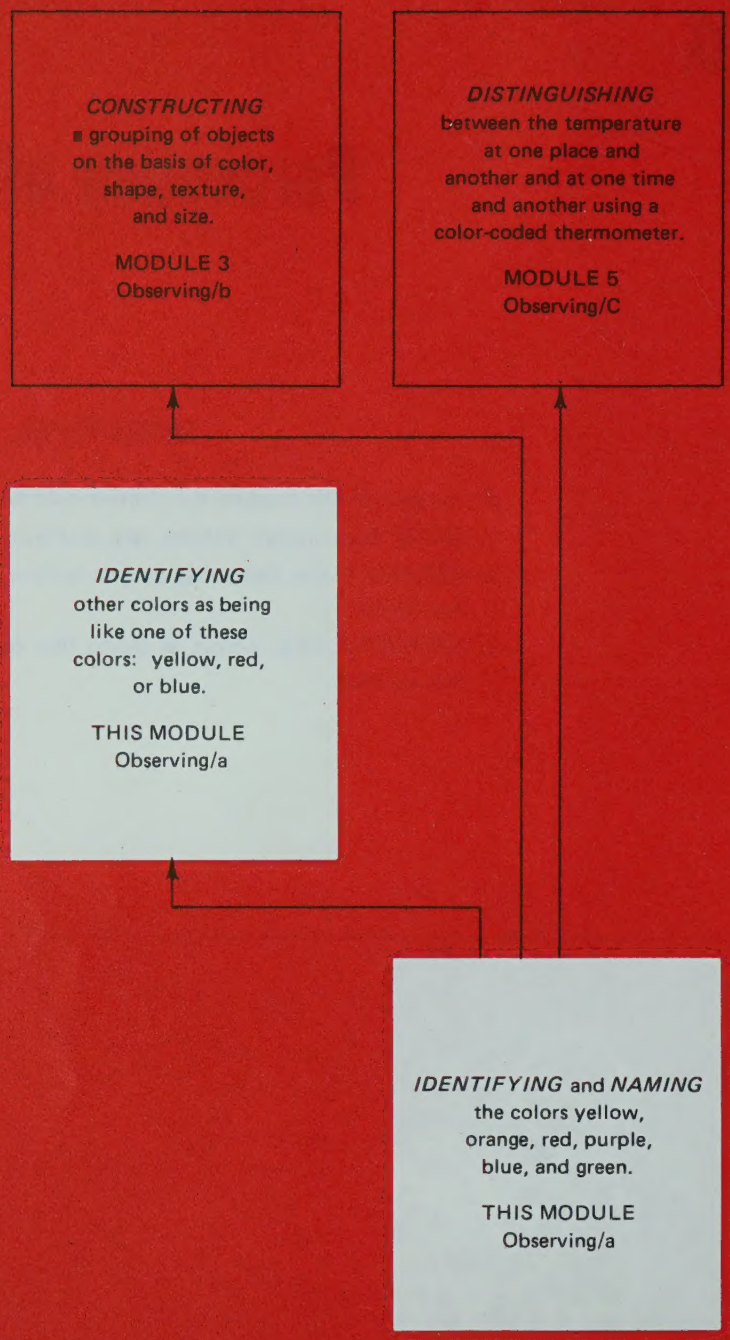
SEQUENCE


CONSTRUCTING
grouping of objects on the basis of color, shape, texture, and size.
MODULE 3
Observing/b
DISTINGUISHING
between the temperature at one place and another and at one time and another using a color-coded thermometer.
MODULE 5
Observing/C
IDENTIFYING
other colors as being like one of these colors: yellow, red, or blue.
THIS MODULE
Observing/a
IDENTIFYING and *NAMING*
the colors yellow, orange, red, purple, blue, and green.
THIS MODULE
Observing/a

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

The purpose of this module is to develop the child's ability to identify and name colors. He should also learn that a specific color name, *red* for example, may be used to name colors ranging through many hues and intensities, since there are many variations within each color name.

Color samples, some of which are not easily classified as blue, red, or yellow, are used to introduce the broad range of colors and the idea that additional color designations are needed. Green, orange, purple, black, white, brown, and perhaps gray complete the list of colors which are considered essential tools the child needs in order to describe, classify, and identify objects according to color. Many young children probably will not be able to recognize and name all of these colors.

The use of common colored objects as comparators will further aid in color identification. Whenever colored materials are used in the modules that follow, the child will have the opportunity to practice color identification and naming. Thus, he should begin to describe colors as similar to materials or objects having such colors: lemon yellow, tomato red, grass green, and sky blue.

Vocabulary

yellow	black
orange	white (optional)
red	gray (optional)
purple	dark
blue	light
green	lighter than
brown	darker than

INSTRUCTIONAL PROCEDURE

Introduction

As each child arrives at school, fasten a red, yellow, or blue paper rectangle on the child's shirt or dress. The paper may have the child's name on it. Comment on the color of the paper rectangle and ask the child to say the name of the color he or she is wearing.

Materials

Rectangles, 30, paper, about 5 x 8 cm, 10 each of the colors red, yellow, and blue (*Module 1*)

Activity 1

Put thirty yellow, red, and blue paper squares in a large bag or small box. Show the children three paper plates: one marked red, one yellow, and one blue. (See *Materials* for suggestion on marking.) These colors should closely match those in the bag. Ask the children to come forward, a few at a time, and let each child take one paper square from the bag and place it on the plate marked with the matching color. (See Figure 1.) As each child takes a

FIGURE 1

colored square, ask him to name the color of that square. If the child hesitates, name it for him.

If this activity seems too simple, begin with *Activity 2* and choose one of the optional activities.

Materials

Bag, 1, paper, large, or a small box
Plates,3, paper, white (*Module 1*)
(Note: Using crayon or paint, mark each plate with a different color: red, yellow, blue.)
Squares, 30, paper, about 5 x 5 cm, 10 each of the colors red, yellow, and blue (*Module 1*)

Activity 2

Place in view the three plates used in *Activity 1.* Put 80 colored squares around the room. The colors should include the basic yellow, red, and blue corresponding to those on the plates, as well as shades and tints such as light red, pink, light blue, and turquoise. Orange, purple, and green should also be included. Because some groups of children will be more ready to work with variations in color hue than others, select color variations which you think are appropriate for the children.

Even though the plates and colored squares are in open view, you can promote the game of hunting. Ask the children to look for the pieces of paper. As a child finds one, ask him to put it on the plate marked with the color which it looks most like. The square need not match exactly. In fact, it is important to avoid giving the idea that it must match. If the children are uncertain about where a color sample belongs, tell them to put it between the two plates marked with the colors it looks most like. When the children have found all the colored squares, then examine the plates with them.

The children are almost certain to have questions concerning the placement of the orange, green, and purple samples. Some of them may suggest the need for other plates.

Now introduce plates marked with orange, green, and purple which are to be arranged in a circle with the other plates. Try to get the children to tell you where the new plates belong by asking such questions as these: Where should we place this plate? Which of the colors is it most like? Through discussion, the children will probably decide that orange belongs between yellow and red, purple belongs between red and blue, and green between blue and yellow. Then ask them to put the orange, green, and purple squares on the appropriate plates. They may not know exactly where to put the pink square. But as they talk about it, children usually will see that pink is more like red than any of the other colors.

Materials

Plates, 6, paper, white (*Module 1*)
Squares, 80, paper, about 5 x 5 cm, 8 each of the colors red, blue, yellow, orange, purple, green, light red, pink, light blue, and turquoise (*Module 1*)

Activity 3 (Optional)

Put the same six plates you used in the previous activity in a circle. Then put four new plates in the center of this circle: one marked with brown, one with black, one with white, and one with gray. Again, scatter paper, felt, or fabric pieces of the fourteen colors around the room. Try to use approximately the same numbers of pieces for each color.

If any child is uncertain about where a color belongs, let the whole class help him decide which color it looks most like. If no one in the class can identify a particular tint or shade correctly, you may wish to put that piece of paper away for consideration at some later time in the school year.

Materials

Plates, 10, paper, white (*Module 1*)
Squares, 112, paper, about 5 x 5 cm, 8 each of the colors red, blue, yellow, orange, purple, green, light red, pink, light blue, turquoise, black, gray, brown, and white (*Module 1*)

Activity 4 (Optional)

If you have a collection of paper and fabric scraps of many hues, you may want to use these materials for a class collage project.

For example, the children may wish to work on one particular collage—perhaps red. Ask them to come in small groups during their free play time, and let them choose two or three pieces from the scrap collection that are most like red. Allow each child to paste or glue his contributions on the same sheet of red construction paper. (See Figure 2.)

The red collage would therefore show many different shades and tints of one hue. Suggest that the children bring from home other small red materials, such as buttons and birthday candles, and glue them to the class collage.

Repeat this activity with other colors if the children maintain interest.

Materials

Scraps, many, paper or fabric, many colors
Paper, several pieces, construction, large, of one or more of the colors covered by the other activities
Glue, 1 bottle

FIGURE 2

Activity 5 (Suggested for more mature children)

Plan an art activity, such as finger painting, to coincide with the teaching of this module. The children might have informal opportunities to discover what happens when one color is combined with another.

Children might experiment with tempera paints, perhaps using white paint and several other colors. They might also use crayons, coloring one hue lightly over another.

Keep this activity informal and pursue it only as far as the children's maturity and interest allow.

Materials

Paints, several bottles, tempera, of many colors

Generalizing Experience

Put five or six large, inflated balloons of a variety of colors around the room. Give each child a colored piece of paper that you may call a ticket. This ticket is an invitation to sit near the balloon with the matching color. When each child is in place, give him a piece of drawing paper and ask him to draw some balloons. Suggest that he color them whatever color or colors he wishes.

Ask each child to name the color or colors he selects for his balloons.

Materials

Balloons, 6, 1 each of 6 colors (*Module 1*)
Squares, 30, paper, about 5 x 5 cm, 5 each of 6 colors (*Module 1*)
Paper, 30 pieces, drawing
Crayons, 6 boxes

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APPRAISAL

Ask each of six children to bring a box of crayons and sit together in some convenient place.

Ask each child to point to his red crayon when you say the word *red.* Repeat this for all six colors.

Ask each child to match one crayon with some article of clothing that someone else is wearing. For example, ask one child to find a crayon whose color is most like Jane's skirt. If Jane's skirt is pale blue, the child should point to the blue crayon.

Before each group of children leaves the activity, ask each child individually to name and point to the red, blue, and yellow crayons.

Materials

Crayons, 6 boxes, each box including a red, green, yellow, blue, orange, and purple crayon

COMPETENCY MEASURE

TASK 1 (Objective 1): Show the child a yellow cube and ask, **What is the color of this cube?**

TASK 2 (Objective 1): Show the child a red cube and ask, **What is the color of this cube?**

TASK 3 (Objective 1): Show the child a blue cube and ask, **What is the color of this cube?**

The child should give the correct name for each cube.

Place an orange, green, and purple cube in front of the child. Say, **The cubes in front of you are orange, green and purple.**

TASK 4 (Objective 2): Say, **Put your finger on the orange cube.**

TASK 5 (Objective 2): Say, **Put your finger on the green cube.**

TASK 6 (Objective 2): Say, **Put your finger on the purple cube.**

The child should correctly identify each cube by placing his finger on the appropriate cube.

Place three large pieces of paper in front of the child: one yellow, one red, and one blue.

TASK 7 (Objective 3): Show a light yellow square and say, **Put this on one of the three colored papers. Which color is it most like?**

TASK 8 (Objective 3): Show a light blue paper square and say, **Put this on one of the three colored papers. Which color is it most like?**

The child should place the light yellow paper square on the yellow paper and the light blue square on the blue paper.

Materials

Cubes, 3, 3-cm, 1 each of the colors orange, green, and purple (*Module 1*)
Cubes, 3, 3-cm, 1 each of the colors red, blue, and yellow (*Module 3*)
Paper, 3 pieces, construction, large, 1 each of the colors yellow, red, and blue
Squares, 2, paper, about 5 x 5 cm, 1 each of the colors light yellow and light blue

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1 Observing/a

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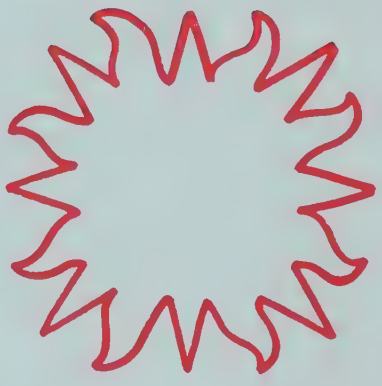

A PROCESS APPROACH II

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SCIENCE... A PROCESS APPROACH II

MODULE

2

Using Space/Time Relationships/a

Recognizing and Using Shapes

OBJECTIVES

At the end of this module the child should be able to

1. *IDENTIFY* common two-dimensional shapes.
2. *NAME* common two-dimensional shapes.
3. *IDENTIFY* the common two-dimensional shapes in objects in the environment.

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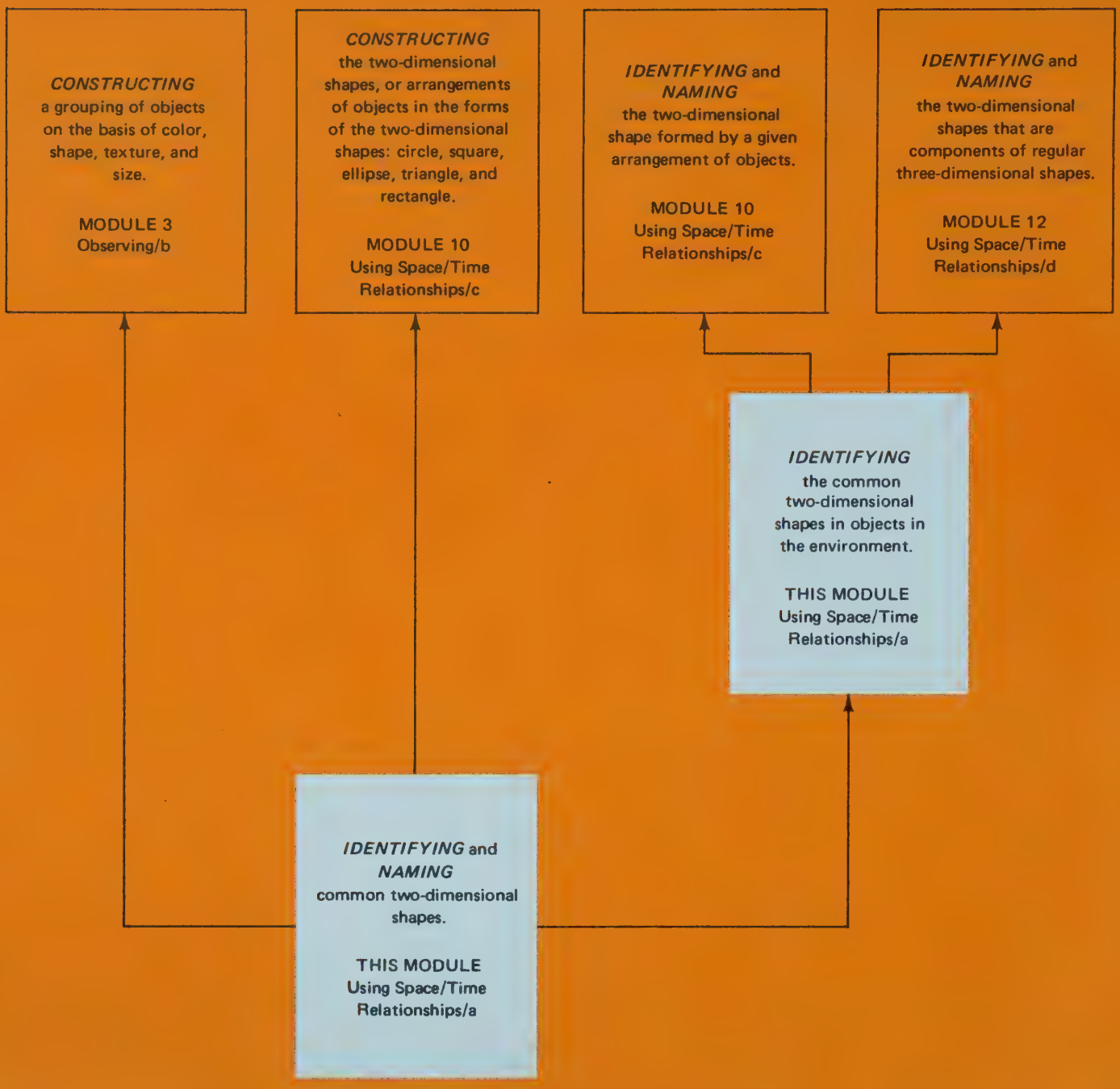
CONSTRUCTING
a grouping of objects on the basis of color, shape, texture, and size.
MODULE 3
Observing/b
CONSTRUCTING
the two-dimensional shapes, or arrangements of objects in the forms of the two-dimensional shapes: circle, square, ellipse, triangle, and rectangle.
MODULE 10
Using Space/Time Relationships/c
IDENTIFYING and *NAMING*
the two-dimensional shape formed by a given arrangement of objects.
MODULE 10
Using Space/Time Relationships/c
IDENTIFYING and *NAMING*
the two-dimensional shapes that are components of regular three-dimensional shapes.
MODULE 12
Using Space/Time Relationships/d
IDENTIFYING
the common two-dimensional shapes in objects in the environment.
THIS MODULE
Using Space/Time Relationships/a
IDENTIFYING and *NAMING*
common two-dimensional shapes.
THIS MODULE
Using Space/Time Relationships/a

Use of this chart, the instruction booklet, and other elements of **Science. . .A Process Approach II**, is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

Acquiring a knowledge of plane shapes is more than merely learning names. It is also, for example, developing the ability to recognize the shapes of objects in the environment. Most important, it is developing the ability to use the names of these shapes to describe familiar as well as novel, complex objects. In later learning, the child will use these concepts in many activities, such as in representing scientific relationships or in devising models to explain scientific phenomena.

As you help the children create and identify some common shapes, you may choose to teach only one shape at a time, introducing them as fast as your group can absorb them. If possible, treat the square and the rectangle as different shapes, and also the circle and the ellipse. In some instances, it may be useful to allow children to conceive of the rectangle as an elongated square, or the square as a special kind of rectangle (all sides having the same length), and the ellipse as a "squashed" circle.

You should not try now to draw the distinction between the "boundary" and the "interior" of shapes, although the shape is actually just the boundary. In this module the concern is with shapes in a primitive sense. Thus, you would refer to a circular cardboard surface as a "circle" rather than as the "interior of a circle." Likewise you would refer to a ring as a "circle."

Activities 4 and *6* are marked "Optional." You may wish to teach these activities in order or save them for use later as a way of helping children review and recall shapes.

Vocabulary

circle	large
rectangle	big
square	small
triangle	wide
ellipse	narrow
edge	long
side	short
shape	(comparative terms
alike	of each of above)
different	

INSTRUCTIONAL PROCEDURE

Introduction

Give each child a cardboard shape—either a square, a rectangle, a triangle, a circle, or an ellipse. Include all of these shapes. With the children seated, show them one shape, such as a triangle. Have those children holding a triangle stand up. Ask them to name the shape. If they do not name the triangle correctly, tell them its correct name.

Ask the children in the group that is standing up to run their fingers around the edge of the triangle so they will become more familiar with it.

Repeat this activity for the four other shapes.

Have the children identify objects in the room that have a shape like the one they are holding. They may not see an ellipse or a triangle in the room, but they should be able to identify objects for the other shapes; for example, a clock is like a circle, a book is like a rectangle. If they have difficulty in doing this, help them by holding up objects with the appropriate shapes. (In *Activity 3* of this module, greater attention is given to this kind of experience. You may wish to teach *Activity 3* before *Activities 1* and *2*.)

Materials

Shapes, 30, cardboard, 6 each of a square, a rectangle, a triangle, a circle, and an ellipse (*Module 2*)

Activity 1

Against the chalkboard, display each of the large cardboard shapes from the previous activity. Put tape on the backs of the shapes to fasten them to the board so that their edges are clearly visible. Review the names of the shapes.

Ask a child to draw around the edge of one cardboard shape with a piece of chalk. (See Figure 1.) Remove the cardboard and ask him to tell you the name of the shape. Then help the child make this shape in the air with his arms. Let another child trace around the next shape on the board and again make the shape in the air. Continue this activity with the other shapes.

Hold up a rectangle and a square. Ask a child to trace one of these shapes in the air and ask a second child to identify it. Make the point that if another person is going to be able to recognize the shape correctly, the arm movements must be made slowly and carefully. Give each child a turn at this.

Let the children do this in pairs or in groups of three or four, with one child outlining the shape with his arms, and the others naming the shape he is illustrating.

To conclude this activity, hold up the wire shapes of a square, a rectangle, a triangle, a circle, and an ellipse. As the children name each shape, let one child tape a name tag on that shape and then place the shape in a convenient location where the children can refer to it until the next activity.

FIGURE 1

Materials

Shapes, 5, cardboard, 1 each of a square, a rectangle, a triangle, a circle, and an ellipse (*Module 2*)
Tape, 1 roll, with adhesive on both sides, or masking tape folded
Shapes, 5, wire, 1 each of a square, a rectangle, a triangle, a circle, and an ellipse (*Module 2*)
Name tags, 5, paper, 1 each for the square, rectangle, triangle, circle, and ellipse

Activity 2

While reviewing the previous activity of forming the five shapes in the air, introduce the notion of size. For example, you might make a little circle with your thumb and index finger and have the children do the same. (See Figure 2.) Then ask them what shape has been formed. Then make a larger circle with both thumbs and index fingers with the children doing the same. (See Figure 3.) Again ask them what shape has been formed. Continue on in the same manner, tracing large and small triangles, rectangles, squares, and ellipses in the air.

Display felt circles of different sizes on a flannel board and ask the children to explain how these circles differ from one another. Do the same for each shape. The children should be able to tell differences in size (as smaller and larger) as well as color.

Materials

Shapes, 15, felt, 3 different sizes and colors each of a circle, a square, a rectangle, a triangle, and an ellipse (*Module 2*)
Board, 1, flannel

FIGURE 2

FIGURE 3

Activity 3

(The identification of single circles, ellipses, squares, rectangles, and triangles is not enough, however. Children should be able to identify these shapes in various combinations and as parts of familiar objects or very different and unfamiliar objects.)

When the children go to the playground, take pieces of colored paper cut in the shapes of circles, ellipses, squares, rectangles, and triangles. (To emphasize shape rather than color, all of the pieces should be the same color.) Make sure that some cubes and rubber balls are among the objects present on the playground. Give each child a paper shape and ask him to find something on the playground or something that can be seen from the playground which suggests the shape of his piece of paper. As a child finds the shape, ask him where it is and what it is. Tell him he may keep the paper shape if he has identified it correctly. Then give him another shape to look for.

After recess, hold up one shape at a time and ask how many found something like it. Then ask each child to call the shape by name and to tell where he saw it, or which part of an object has that shape. Be sure that each child can identify all five basic shapes as parts of other objects.

Some of the children may have matched up squares to cubes and circles to rubber balls. Hold up a cube and a cardboard square in front of the class. Tell those children who selected the cube as an illustration of the square shape that they were right—that it is an example of a solid shape, known as a *cube*, which has square sides. Now hold up a rubber ball and a cardboard circle in front of the children. Tell those children who selected the rubber ball as an illustration of a circular shape that they were right—that the rubber ball is an example of a solid shape, known as a *sphere*, which is a circular solid.

At this point, it is not necessary that the cube and the sphere be discussed further. The possibility for introducing them will probably arise because the connection will be obvious to some children. If this connection occurs to them naturally, there is no reason to delay the identification. In fact, such identifications will help children's readiness for activities in subsequent modules.

Materials

Shapes, 60, paper, one color, 12 each of a circle, a square, a rectangle, a triangle, and an ellipse (*Module 2*)
Cubes, 3, about 7-cm (*Module 3*)
Ball, 3, rubber
Shapes, 2, cardboard, a square and a circle (*Module 2*)

Activity 4 (Optional)

Let the children play one or more of the following games on different days:

Game 1. Spread the fifteen felt shapes on a table that is visible to all children. Ask one child to think of one felt piece and to whisper his choice to another child. Then tell the other children to ask the second child (the one who knows what was chosen, but who did not make the choice) questions such as these: Is it a square? Is it the largest square? Is it the smallest square? Is it the smallest green square?

(The technique of questioning is one which has to be taught, and children need guidance at first. To encourage participation, you may begin with a statement such as this: I am thinking of a shape.)

Game 2. Ask one child to select one of five cardboard shapes and show it to the rest of the children. Ask the children to look around the room and find shapes similar to the one which the first child is holding. They may compare a rectangle with the door, a window, or a picture, and a circle with the doorknob, the wastebasket, or a paper cup. Emphasize the contrast in the sizes of their examples—that is, the difference in size between the door and a ruler, or a window and a crayon box.

Game 3. Ask one child to select an object anywhere in the room which is shaped like a circle, triangle, square, rectangle, or ellipse. Let the others take turns in trying to determine what object the first child is thinking about by asking questions which can be answered by either "Yes" or "No." Try to exhaust the possibilities in the room by letting the children take turns thinking of objects which exemplify the shapes being taught.

Materials

Shapes, 5, cardboard, 1 each of a square, a rectangle, a circle, a triangle, and an ellipse (*Module 2*)

Shapes, 15, felt, 3 different sizes and colors each of a square, a rectangle, a circle, a triangle, and an ellipse (*Module 2*)

Activity 5

Put a rectangle, with its longer sides in a horizontal position, on a flannel board. Ask the children if they can think of a toy that has a part that looks like a rectangle. They may suggest several things; among them, a wagon. If they do say wagon, ask what is needed to make a picture of a wagon from the felt rectangle. They may then say wheels. If not, ask them if they can think of a useful toy that has rectangles and circles as important parts of it. To start the body of the wagon, let the children put the circles on the rectangle. Also let them place a long rectangular strip for a tongue, as in Figure 4.

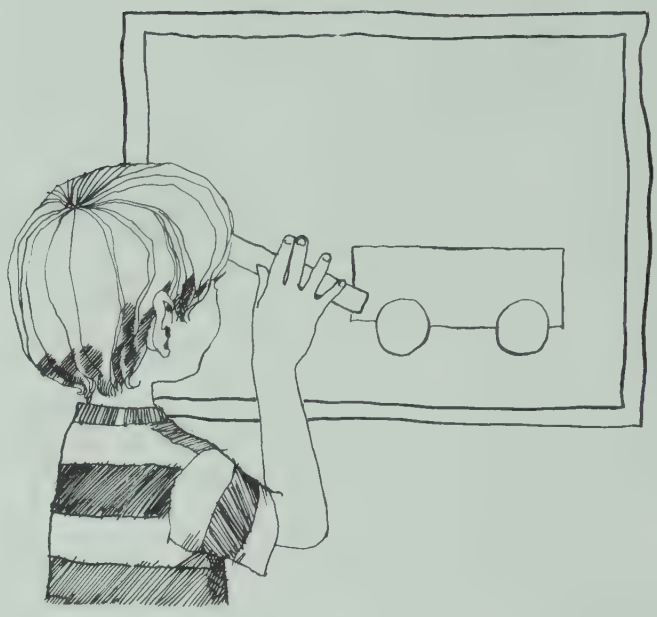

FIGURE 4

Show the children the rectangular box from which a wagon can be made. As you point to one side of the box, ask them what the shape is. Point to other sides and ask similar questions. Help them to use the word *rectangle* freely. In turn, show them the circles, ellipses, squares, and triangles which are made of wood. Ask questions about the shapes and make sure that the children name them properly.

Then ask the children what might be made out of the box. Someone may suggest making a wagon out of it. If not, hold up several of the wooden shapes and ask whether the children have ideas about how to place the shapes on the box to make it useful. The children will most likely suggest using the circles as wheels. Invite individual members of the group to help put the circles in place.

One of the children may suggest using one of the ellipses as a wheel. If no child does, you should suggest it as a possibility and ask the children if the ellipse makes a satisfactory wheel.

Now ask questions such as: Can we use our new wagon now? What do we need to make our wagon more useful? Ask a child to look among the pieces to find a shape which could be used to make a complete wagon. (He may select a rectangle which can be used as a tongue for the wagon.)

Put the wagon with its spare "wheels" (ellipses, squares, rectangles, and triangles) in a part of the room where the children can explore it in their free time. Later, ask the children what they have discovered about using the various shapes as wheels. Conclude by asking a question such as: Which shapes are the most practical for use in making a wagon?

Materials

Board, 1, flannel
Shapes, 4, felt, 1 large rectangle, 2 circles, and 1 long rectangular strip (*Module 2*)
Wagon set, 1, consisting of a rectangular box, 4 large circles, 4 small circles, 4 rectangles, 4 triangles, 4 ellipses, 4 pins, and 1 handle (*Module 2*)

Activity 6 (Optional)

(This activity may be interesting for more mature children.)

The ellipse, a special curved figure, is used both in science and art. Discuss the following ideas with the children. If you place a circle on the wall and view it from an angle, it will look like an ellipse. The hoop on the basketball backstop or the top of a wastebasket are actually circular, but they appear elliptical when viewed from the side. The surface of water in a cylindrical drinking glass is circular when looked at straight down from the top, but if the glass is tipped or the water surface is viewed through the side of the glass, the surface seems to have an elliptical shape. Coloring the water makes the elliptical shape more apparent.

The children may enjoy constructing an ellipse as follows.

Step 1. Take a stiff piece of cardboard about 50 x 75 centimeters, punch two small holes in it about 25 centimeters apart, and put a thumbtack in each of the holes. Each tack will be a focus of the ellipse, just as the center of a circle is the focus of the circle. (The plural of *focus* is *foci,* pronounced fō sī.)

Step 2. Now put this cardboard with the tacks in it on a drawing board or a table. Make a closed loop of string large enough to fit loosely outside the chosen foci as represented by the tacks. (Make sure there is some slack in the loop.)

Step 3. Place a marking pencil or crayon in the loop of string, keeping the string taut against the foci as you form a triangle. Now draw the ellipse, always keeping the string taut and on the foci as the crayon is moved. Figure 5 shows the construction.

You can make ellipses having different proportions by changing the positions (distance apart) of the thumbtacks and the length of the string.

You might ask the children what shape they think would be drawn if only one thumbtack is used. Let them try it.

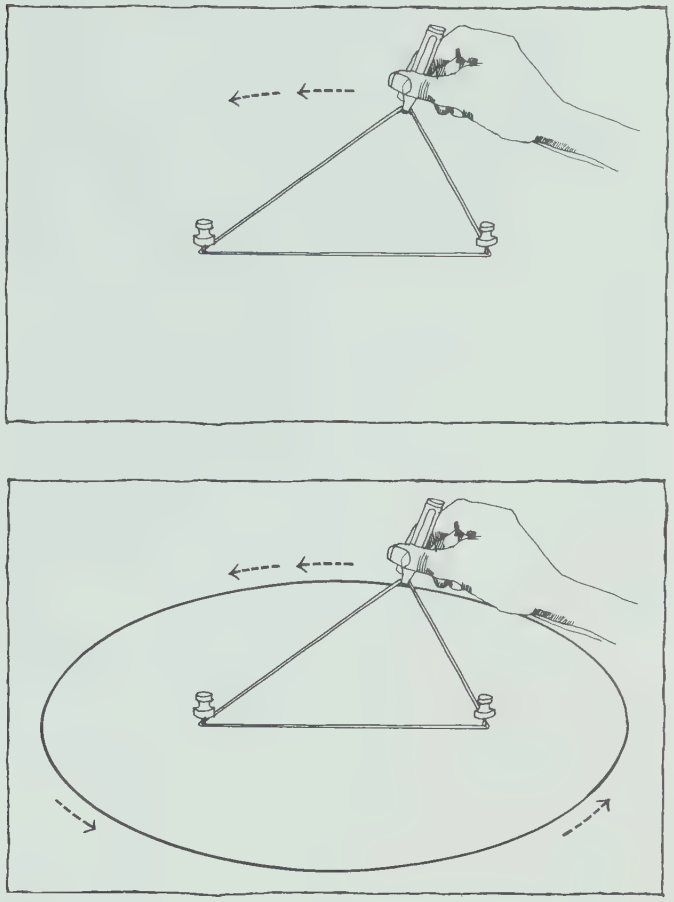

FIGURE 5

Materials

Glass, 1, drinking
Circle, 1, cardboard (*Module 2*)
Cardboard, 1 piece, about 50 x 75 cm, stiff
Thumbtacks, 2
String, 1 piece, about 50 cm long

Generalizing Experiences

(Use two or three.)

1. Put a felt triangle on a flannel board. Make sure one of its sides is in a horizontal position. Ask one of the children to find another piece which could be used to help make a picture of something. For example, a child might place a square below the triangle to make a tree. Let children explore other possibilities for making objects using the given felt shapes.

2. Ask the children to bring shapes from home—magazine pictures, toys, and so on. They may want to group what they bring under the name labels for the five shapes, or they may make scrap books or table displays.

3. Folding carpenter's rules are very dramatic in forming shapes bounded by straight lines. After a brief demonstration and some appropriate questions, leave one or two of these on a table where the children can use them in their free time.

4. Show the children how to use a pegboard and rubber bands to make shapes.

Materials

Board, 1, flannel
Shapes, collection, felt, of the five discussed shapes (*Module 2*)
Name tags, 5, paper, 1 each for the square, rectangle, triangle, circle, and ellipse
Rule, 1, carpenter's
Rubber bands, 1 box
Pegboard, 1 (*Module 2*)
Pegs, 1 box (*Module 2*)
Shapes, collection, magazine pictures, toys, and other objects

APPRAISAL

Put all the different cardboard, paper, and felt shapes used in this module in a pile on the floor. Ask a child to find a circle in the pile and to put it on a table. Ask another child to select a rectangle, square, triangle, or ellipse, and to bring it to the table to start another group. Continue to call on children to select shapes until all of these shapes have been carried to the table. See if the children can select the correct ones.

Have one child hold up a shape and ask another child to name it. Let this continue until every child has been included.

Place a collection of children's toys (such as trucks, cars, airplanes, and wagons) on a front table. Ask individual children to try to find examples of circles, rectangles, squares, triangles, and ellipses in these toys. See if the children can identify common two-dimensional shapes in these objects.

Materials

Shapes, collection, of cardboard, paper, and felt used in activities (*Module 2*)
Toys, collection, of trucks, cars, airplanes, wagons

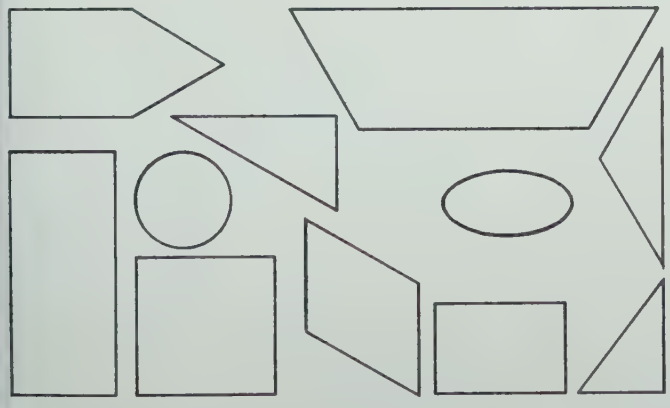

FIGURE 6

COMPETENCY MEASURE

Show the child a collection of paper shapes which includes these:

TASK 1 (Objective 1): Say, Show me the square. The child should indicate the square.

TASK 2 (Objective 1): Say, Show me the ellipse. The child should indicate the ellipse.

TASK 3 (Objective 2): Pick up a rectangle. Say, Name this shape. The child should say, "rectangle."

Place a collection of objects on a table near the child. Include such objects as: a coin, a bottle cap, a small box, a ruler, a triangular-shaped solid, a musical triangle, a wooden cube, a bowl having an elliptical shape, and a toy tire or wheel.

TASK 4 (Objective 3): Say, Which of these objects has a circle on it? The child should select the bottle cap, coin, or other circular object.

TASK 5 (Objective 3): Say, Which of these objects has a triangle on it? The child should select the musical triangle, the triangular solid, or other triangular object.

Materials

Coin, 1
Bottle cap, 1
Box, 1, small
Ruler, 1
Pyramid, 1 (*Module 12*)
Triangle, 1, musical
Bowl, 1, of an elliptical shape
Tire, 1, toy, or wheel
Cube, 1, about 3-cm (*Module 3*)
Shapes, 11, paper, different shapes, but 1 each of a square, rectangle, triangle, circle, and ellipse (*Module 2*)

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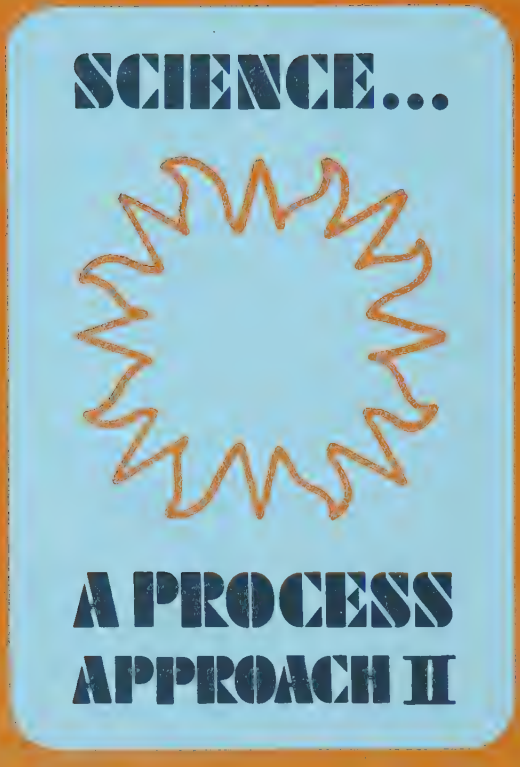
2 Using Space/Time Relationships/a



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SCIENCE... A PROCESS APPROACH II

MODULE

3

Observing/b

Color, Shape, Texture, and Size

OBJECTIVES

At the end of this module the child should be able to

1. *IDENTIFY* an object on the basis of color, shape, texture, and size.
2. *NAME* two or more characteristics of an object from the following characteristics: color, shape, size, and texture.
3. *CONSTRUCT* a grouping of objects on the basis of color, shape, texture, and size.

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SEQUENCE

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RATIONALE

In this module the children learn to combine visual observation skills by identifying objects on the basis of both color and shape. In addition they observe relative sizes and identify objects as large and small. They learn that the sense of touch can also be used to observe; they *feel* objects and describe them as rough or smooth. The vocabulary and the skill in making visual and tactile observations will help them describe the objects, places, and situations of their environment.

You should feel free to expand the vocabulary beyond the words *rough* and *smooth* if you feel that doing so will make using the sense of touch easier for the children or if the objects cannot be described adequately with these words. You or the children might suggest the words *hard*, *soft*, or *bumpy*.

(Note: The materials listed are sufficient for this module. If other cubes and spheres are available, you may want to expand the supply you show the children and make corresponding changes in the questions and procedures.)

Vocabulary

rough	different
smooth	texture
small	pair
large	cube
object	sphere
same	group

INSTRUCTIONAL PROCEDURE

Introduction

Place pairs of cubes and pairs of spheres about the classroom where children can conveniently observe them. (See Figure 1.) The members of each pair should be identical except for texture. For example, a pair might consist of two large, red cubes—one rough and the other smooth. Encourage the children to handle the shapes and to discuss how they are alike and how they are different.

Materials

Cubes, 12; large and small; rough and smooth; yellow, red, and blue (*Module 3*)

Spheres, 12; large and small; rough and smooth; yellow, red, and blue (*Module 3*)

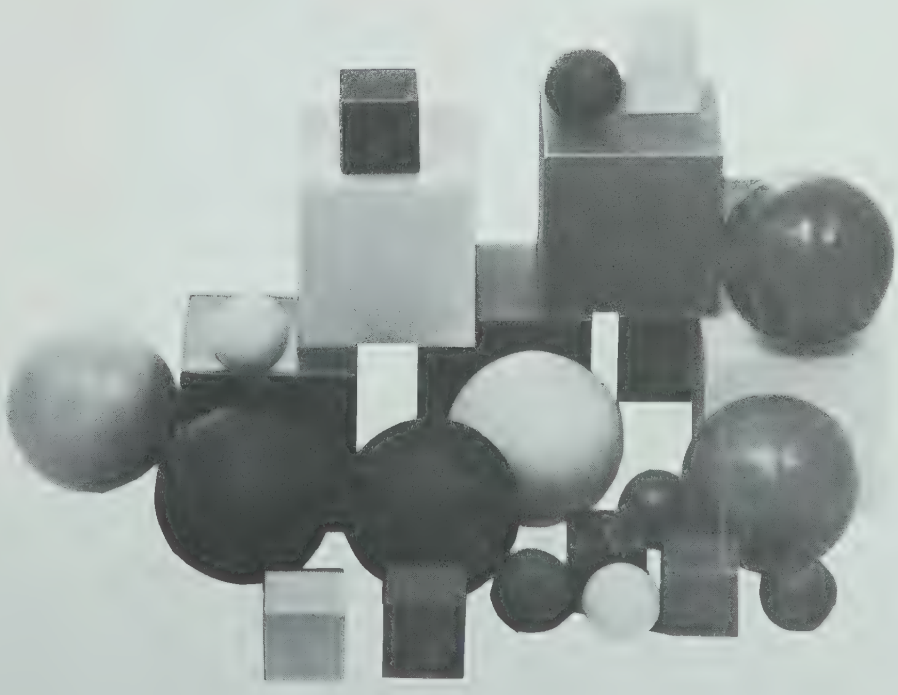

FIGURE 1

Activity 1

Select a cube and ask the children to describe it. Ask the children what they have noticed about the object. How many things can they tell you about it? Do the same with the sphere. Make sure the children are familiar with the names of these objects since these names have only been mentioned briefly up to now.

Choose a pair of objects which are identical except for texture. Ask the children what is the same about these objects. Ask them what is different.

If the children do not mention texture, then pass the pair of objects around the room, giving each child a chance to feel the objects. Then ask them again what is different about these objects. Now start with a smooth object. Ask them if they can find anything else in the room that feels the same way. Give the children an opportunity to find other smooth objects—possibly a desk top or the chalkboard. Supply the word *smooth* if the children cannot.

Ask the same question about a rough object. Ask the children what other objects feel the same way. (Possible examples are concrete sidewalks, perhaps a piece of dry toast, or sandpaper.) Supply the word *rough* if necessary.

Have available as many spheres and cubes as possible. Allow the children to touch and handle them. You might ask small groups of children to put all the smooth ones in one group and all the rough ones in another group.

Materials

Cubes, 12; large and small; rough and smooth; yellow, red, and blue (*Module 3*)

Spheres, 12; large and small; rough and smooth; yellow, red, and blue (*Module 3*)

Activity 2

Hold up a sphere or a cube and ask individual children to name the color of that cube or sphere. Review the colors as needed.

Again hold up a sphere or cube, but this time ask individual children to name its shape. Review the shapes as needed.

Tell the children to use the words *large* and *small*, and ask them to illustrate with appropriate objects.

Ask how a particular object feels. Is it smooth or is it rough?

Give verbal descriptions of objects and have children select the appropriate objects. Ask such questions as:

Can you find a blue cube? (Either blue cube is acceptable.)

Can you find a rough, blue cube?

Who can find a small, rough, red cube?

Who can find a large, smooth, yellow sphere?

Continue giving other descriptions until the children can identify objects according to their color, shape, texture, and size.

Point to a particular object and ask each child to give a verbal description of it. For example, the child might say:

"It is a blue cube."

"It is large and smooth."

"It is a small, rough, red sphere."

Let others help any child who seems unsure or who fails to mention a particular characteristic.

Materials

Cubes, 12; large and small; rough and smooth; yellow, red, and blue (*Module 3*)

Spheres, 12; large and small; rough and smooth; yellow, red, and blue (*Module 3*)

Activity 3

The following game will test children's ability to identify one object by knowing its color, shape, size, and texture.

Put all the objects used in *Activity 2* in the back of the room and have the children face the front. Ask one of the children to select one of the objects and place it in a paper bag. Such a bag might be called the "mystery bag." Only the child who selected the object will know what it is. The rest of the children are to find out what the object is by asking questions until they can correctly identify the object. Help them to see that they can usually identify the object with a minimum number of questions if they will first ask questions about one category at a time. For example, "Is it yellow?" is more helpful than "Is it the large, rough, yellow sphere?"

The teacher may have to help the children recall the answers previously given by making a statement such as: We already know that it is blue, rough, and a cube. What else do we need to know?

Materials

Cubes, 12; large and small; rough and smooth; yellow, red, and blue (*Module 3*)
Spheres, 12; large and small; rough and smooth; yellow, red, and blue (*Module 3*)
Bag, 1, paper

Activity 4

Put all of the cubes together in one place. Ask the children what different kinds of cubes they can see. (Large, small, rough, smooth, red, yellow, or blue.)

Ask what kind of a group they would call all of these. Now have the children make up groups according to your directions. Ask such questions as: Who can make up a group of yellow cubes? Red cubes? Blue cubes? Rough cubes? Smooth cubes? Large cubes? Small cubes?

Repeat the process with spheres.

Ask for one rough, small, red cube (in order to introduce a group consisting of only one member).

Materials

Cubes, 12; large and small; rough and smooth; yellow, red, and blue (*Module 3*)
Spheres, 12; large and small; rough and smooth; yellow, red, and blue (*Module 3*)

Activity 5 (Optional)

Have each child bring in an object from home. Stress that the object should be of a color and shape studied. Play a game in which a child having an object with all the characteristics named would stand up, go to the front of the room, or do some other similar activity. For example, the teacher might make such statements as: Will all the children holding a smooth object stand up. Will all the children with a smooth, yellow object go to the front of the room. Will all the children with a smooth, yellow, large object stand near the windows. Continue on with such statements so that all the characteristics are covered.

If a child gets up when he shouldn't or doesn't get up when he should, discuss the object with the whole class. Continue on until children seem quite competent with this or until interest fades.

Materials

Cubes, 12; large and small; rough and smooth; yellow, red, and blue (*Module 3*)
Spheres, 12; large and small; rough and smooth; yellow, red, and blue (*Module 3*)
Objects, collection

Generalizing Experience

A good collection of materials for further work could include an assortment of fruit, such as yellow and red apples, green and blue grapes, lemons, limes, oranges, grapefruit, and bananas. Repeat the question-and-answer game described in *Activity 3.* Afterwards, wash the fruit and let the children eat it.

Materials

Fruit, an assortment

APPRAISAL

See if the children can form groups in various ways. They should be able to respond correctly, individually or in small groups, to requests such as these:

Make a group of all the smooth cubes.
Make a group of all the red cubes.
Make a group of all the rough spheres.
Make a group of all the blue spheres.
Make a group of all the small objects.
Make a group of all the smooth objects.

Besides being able to pick out groups of objects, each child should be able to respond successfully to requests for specific objects, such as a request similar to this: Select the small, yellow, rough cube.

Each child should also be able to describe an object in two or more ways. For example, if he is shown a sphere that is rough, large, and red, he should be able to mention at least two of these characteristics.

Materials

Cubes, 12; large and small; rough and smooth; yellow, red, and blue (*Module 3*)
Spheres, 12; large and small; rough and smooth; yellow, red, and blue (*Module 3*)

COMPETENCY MEASURE

Put on a table in front of the child the total set of cubes and spheres, including the small, smooth cubes colored green, purple, and orange. Also place on the table the set of smooth and rough triangles.

TASK 1 (Objective 1): Tell the child, **Point to the large, yellow cube.** The child should point to the large, yellow cube.

TASK 2 (Objective 1): Tell the child, **Point to the small, blue sphere.** The child should point to the small, blue sphere.

TASK 3 (Objective 2): Point to the large, smooth, red object. Say to the child, **Tell me everything you can about this object.** The child should name at least two characteristics (large, red, smooth, sphere).

TASK 4 (Objective 2): Show the child the small, smooth, green cube and say, **Look at this object and feel it. Then tell me everything you can about it.** The child should name at least two characteristics (small, green, smooth, cube.)

TASK 5 (Objective 3): Put a small tray in front of the child and say, **Put all the blue spheres on this tray.** The child should group all of the blue spheres together.

TASK 6 (Objective 3): Tell the child, **Make a group of the rough triangles.** The child should group just the rough triangles.

Materials

Cubes, 12; large and small; rough and smooth; yellow, red, and blue (*Module 3*)
Spheres, 12; large and small; rough and smooth; yellow, red, and blue (*Module 3*)
Cubes, 3, smooth, 3-cm, of the colors green, purple, and orange (*Module 1*)
Tray, 1
Triangles, 3, cardboard (*Module 2*)
Sandpaper, 2 sheets, 10 x 10 cm, medium coarse (*Module 3*)
(Note: Cut the sheets diagonally to yield four triangles.)

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3 Observing/b

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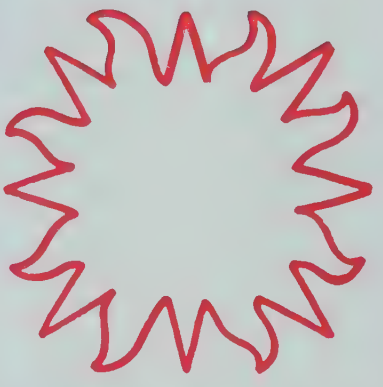

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SCIENCE... A PROCESS APPROACH II

MODULE

4

Classifying/a

ALTERNATE TOPICS:

Leaves, Nuts, and Seashells

OBJECTIVES

At the end of this module, the child should be able to

1. *CONSTRUCT* a classification of objects according to variations in a single characteristic which has been specified by someone else.
2. *CONSTRUCT* a classification of objects according to variations in a single characteristic which he has chosen.
3. *DESCRIBE* the method of classification.

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SEQUENCE

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RATIONALE

All of us classify objects and use classification schemes every day. We classify stores into such categories as drug, hardware, or grocery. Businesses and services of many types are grouped in the classified section of the telephone book. Classification schemes are used in science, as well as in other studies, to show similarities, differences, and interrelationships.

For this module choose one of three possible topics: *Leaves, Nuts,* or *Seashells.* Your choice may be determined by availability, time of year, or whatever may currently have captured the children's interest. The *Generalizing Experience, Appraisal,* and *Competency Measure* are suitable for any one of the three options.

Leaves are perishable, but where they are available, they are abundant and children like to gather them. They may be preserved for a time by pressing (in a large telephone book, for example), by sealing them in food-wrap bags, or by the method described in the *Introduction* of *Leaves.*

Unshelled mixed nuts are good to use because they are reasonably durable and the children can handle them easily. They may be classified by common names, by surface (as hard or soft, and smooth or rough), and by shape; but they are not as satisfactory as leaves for classification by color or size.

Shell collections may be available in some areas of the country, and children will enjoy using them. It is suggested that this option be used only in classes where a number of the children already have an interest in shells and a shell collection.

You may want to use other objects for classification. However, be sure that such objects can be classified in several ways (color, size, shape, kind), and that there are three or four varieties of each of these characteristics.

In teaching this module introduce the words *set* and *member of a set.* Use of these words will provide preparation for the module, *Sets and Their Members, Using Numbers a, Module 9.*

Vocabulary

arrange	flat
classify	texture
divide	group
differ	match
set	member of a set
pointed	

INSTRUCTIONAL PROCEDURE

Alternate Topic: Leaves

Introduction

Bring in a few colorful autumn leaves and ask the children to do the same. You may wish to plan a walk to gather leaves. Encourage the children to talk about the leaves they find or that you or other children bring to school. Suggest that they describe the leaves they select by stating their color, their size, their shape (do they look like a circle?) and their texture (are they rough or smooth, or thin or thick?). Ask questions such as: Have you noticed different-colored leaves on the ground? What colors did you see? Were some leaves large and some small?

Encourage children to discuss characteristics of the leaves with each other.

Materials

Leaves, 300, autumn, of varying color, size, shape, and texture

(Note: If you want to press or preserve leaves so that they can be used for a longer time, arrange a leaf or collection of leaves on a piece of waxed paper, cover this with another piece of waxed paper, and press with a warm iron. Press from the center of the paper toward the outer edge to remove air and seal the waxed sheets firmly. To preserve leaves for shorter periods of time, seal them in food-wrap bags.

Number of leaves here is only approximate. These leaves will also be used for the next four activities.)

Activity 1

Select three leaves which are different in at least one conspicuous aspect (shape, size, color) and tack them on the bulletin board about one meter apart. (See Figure 1.) In this activity, wide contrast among the three leaves chosen is desirable. Pass out leaves of various shapes and sizes so that each child has one leaf. Ask the children (two or three at a time) to come forward and tack their leaves next to the leaf on the bulletin board which they think their leaves most resemble. Accept each child's decision. Do not try to divert him. Ask several children to tell why they placed their leaves where they did.

Use the word *set* as you refer to each group of leaves the children are making. As a child adds a leaf to a group, you might ask in which set he is placing his leaf.

Materials

Leaves, 33, autumn, of varying color, shape, size, and texture
Thumbtacks, 1 box

Activity 2

Ask each child to take a leaf from a collection on a table. Ask two children who have leaves that are quite different in any clearly recognizable characteristic to put theirs on opposite sides of the bulletin board. Ask the class how these two leaves are different.

Responses might include statements like these:

"That one is prettier."
"They are different colors."
"One is bigger."
"This one is rounder."
"That one is wavy around the edge."

Through discussion decide which difference will be used as a basis for grouping. Then, have the children use that basis for grouping as each child who wishes to do so comes forward to put his leaf in the appropriate place on the bulletin board. Ask whether other children agree with the grouping as the leaves are put on one side or the other of the board. Use the correct names for the leaves when appropriate, but do not require the children to learn the names.

As the children are placing their leaves on the bulletin board, refer to the two sets of leaves. Ask such questions as: In which set does your leaf belong? Is it a member of this set? Why did you place it in that set?

Materials

Leaves, 30, autumn, of varying color, shape, size, and texture
Thumbtacks, 1 box

FIGURE 1

Activity 3 (Optional)

Select three leaves of quite different sizes and ask a child to arrange them on the bulletin board in order of size with space between for inserting other leaves. Select another leaf and ask another child to put it on the bulletin board in the appropriate place according to size. Repeat this with several more leaves. Encourage discussion of differences of opinion about relative sizes. For example, ask the children how they can compare sizes of elm and maple leaves. Let the children decide their criteria for size.

Distribute five leaves to each table or working center. Ask one child at each table to be the group leader. Suggest that half the groups arrange leaves from small to large and that the others arrange leaves from large to small. The working groups should discuss freely among themselves their methods of describing and classifying the leaves.

Ask the children to suggest other objects that could also be arranged by size.

Materials

Leaves, 20-30, autumn, of varying color, shape, size, and texture
Thumbtacks, 1 box

Activity 4 (Optional)

Arrange a large leaf, a middle-sized leaf, and a small leaf some distance apart on a bulletin board. Ask several children to place their leaves on the bulletin board close to the leaf which is about the same size as theirs. The children's leaves should include two or more varieties that are not the same as the ones you put on the board.

Point to one of the three sets of leaves and ask the children whether they can group the leaves in this set in some way. The children may decide to group the leaves according to color or shape. The same subgrouping can be made for the other two sets of leaves.

Materials

Leaves, 20-30, autumn, of varying color, shape, size, and texture
Thumbtacks, 1 box

INSTRUCTIONAL PROCEDURE

Alternate Topic: Nuts

Introduction

Bring in a few nuts of several different kinds. (See Figure 2.) You may wish to ask the children to bring in nuts too if they have some at home. In certain localities in the fall it might be possible to gather nuts.

Encourage the children to talk about the nuts on display. Suggest that they describe the nuts they selected by stating their size (small or large), their shape, and their texture. They may also talk about color, but color variations are not great with nuts.

Materials

Nuts, 8 each of at least 4 kinds, such as pecans, Brazil nuts, almonds, acorns, hazel nuts, walnuts, peanuts, chestnuts, and pistachio nuts; all nuts in shells

Activity 1

Set aside 18 nuts, six each of three different kinds. Make 18 sample cards by gluing each of the 18 nuts on a separate card. Arrange the cards into sets of three so that each set has three different samples. Put each set in a work area for a group of four or five children.

Give each group of children a mixture of these three kinds of nuts. Ask one child in each area to be the group leader as the children sort their samples into three piles, one next to each card, so that the nuts in each pile are like the one on the card.

Refer to the piles as sets of nuts by name—that is, the set of walnuts or the set of pecans. As a child places another nut in the correct pile, call that nut a member of the set.

Materials

Nuts, 18 each of 3 different kinds
Cards, 18, index
Glue, 1 bottle

FIGURE 2

Activity 2

In this activity the children should select the characteristic which they will use in placing the nuts in at least two sets. One possibility is the shape of the nuts.

Let them suggest groupings according to shape. Ask about those most like round balls, those with points, or those with flat sides. When appropriate shape categories have been defined, give each child or each group of children a collection of mixed nuts to sort accordingly. When the grouping is completed, ask the child to describe the nuts in the two (or more) sets he has formed.

Let the class suggest other modes of classifying. The samples may lend themselves to the sorting of one particular kind of nut according to the size of the individual nuts. For example, peanuts may be single or double. The children may suggest ways of sorting the mixture according to color. As much as possible, encourage the children to talk about the classification bases that they have developed.

Materials

Nuts, 8 each of at least 4 kinds, such as pecans, Brazil nuts, almonds, acorns, hazel nuts, peanuts, chestnuts, and pistachio nuts; all nuts in shells

Activity 3 (Optional)

Select three nuts of quite different sizes and ask a child to arrange them on a table in front of the room in order of size with space between for inserting other nuts. Select another nut and ask another child to place it on the table in the appropriate place according to size. Repeat with several more nuts. Let the children decide their own criteria for size.

Distribute four or five nuts to each table or working center and ask the children to arrange them small to large, or large to small, in order of size. The working groups should discuss among themselves and with the teacher their criteria for size.

Encourage the children also to talk about other objects that can be arranged according to size.

Materials

Nuts, 8 each of at least 4 different kinds, such as pecans, Brazil nuts, almonds, acorns, hazel nuts, walnuts, peanuts, chestnuts, and pistachio nuts; all nuts in shells

Activity 4 (Optional)

For those children who are interested, plan this activity involving a two-stage classification. Divide the children into groups of two or three and give each group a set of 12 or more nuts. Ask them to separate the nuts into two sets using a characteristic they choose (kind of nut, size, texture, color). Then ask them to divide each set according to some new characteristic.

As the children work encourage them to tell you about the characteristic they chose by telling you why any given nut is placed where it is.

Materials

Nuts, 48 or more, 8 each of at least 4 kinds, such as pecans, Brazil nuts, almonds, acorns, hazel nuts, walnuts, peanuts, chestnuts, and pistachio nuts; all nuts in shells

INSTRUCTIONAL PROCEDURE

Alternate Topic: Seashells

Introduction

Place five to eight shells on a table. Encourage the children to handle them and to ask questions about them. Select one of the shells for the class to discuss. Encourage discussion suggested by questions which the children ask. Watch for and answer such questions and statements as:

"Where did you get it?"
"What is its name?"
"Is there an animal in it?"
"Where could I get one?"
"I have a shell like that."
"I have a different kind of shell."

Proceed with one of the children's questions or statements and encourage more discussion. Ask the children how they might find out whether there is an animal in this shell. Listen for an answer such as: "Look inside of it or smell it." Let the children carry out their suggestions by looking at and smelling the shell. Let each child have a turn.

Ask the child who says he has a shell to tell how it is like this one or different from another. Suggest that each child who has shells at home bring them to school the next day.

Materials

Shells, 8 (*Module 4*)

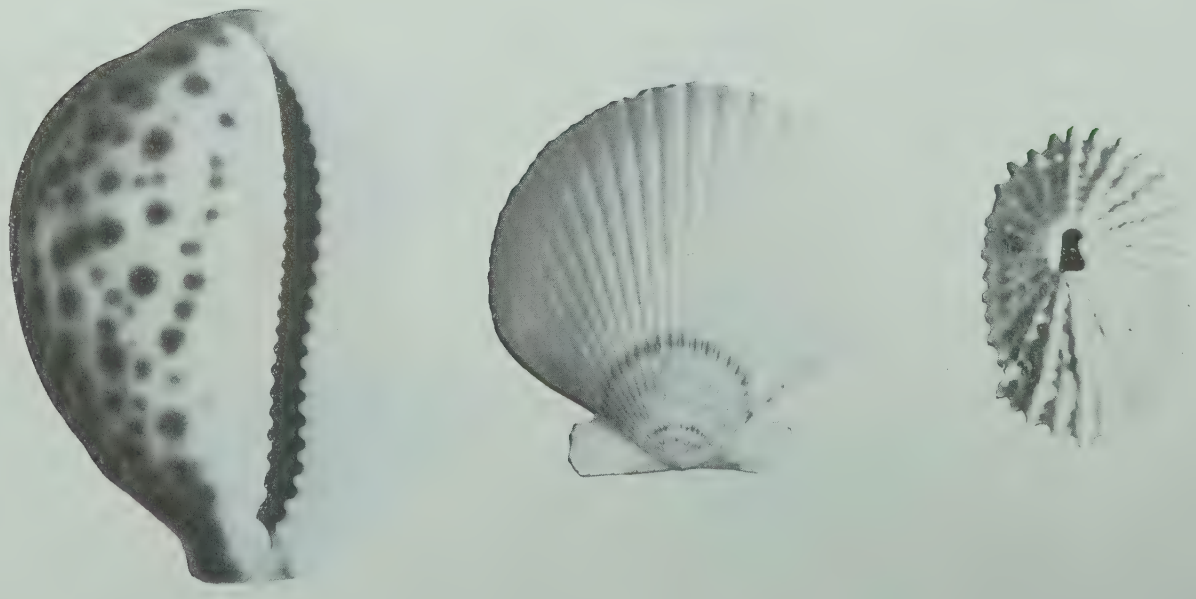

FIGURE 3

Activity 1

Place three shells of quite different characteristics, such as a cowrie shell, a scallop shell, and a volcano shell, on a table in clear view of the children. (See Figure 3.) Place other shells, including those which children have brought from home, on a table nearby. Choose one of these and ask the children to discuss how it is like or different from each of the three shells on the table. Ask the child who brought the shell to place it near the shell on the table which it is most like. (It is advisable to emphasize similarities here.) Ask the child why he decided to place his shell where he did. Repeat this procedure with other shells and continue until three sets of shells have been developed, one around each of the original three.

Encourage the children to look at and handle the shells during their free time, but to keep the three sets separate.

Materials

Shells, 8 (*Module 4*)
Shells, a large assortment of different kinds

Activity 2

Using the sets of shells developed in *Activity 1*, put the set of shells which most resembles the cowrie shell on one tray and those which most resemble the scallop shell on another. (The set of volcano shells will not be used.) Ask the children to look carefully at the set of shells which they placed with the scallop to see if these shells have something which the shells in the other set do not have. Make it easier for the children by holding up a shell from one tray in one hand and a shell from the other tray in the other hand. Put these shells back on the trays and pick up two more of the shells, taking one from each tray. Continue this until all children have seen several pairs of shells and they begin to offer opinions and descriptions of how the two sets differ. Emphasize the idea that all the shells in each set have certain similarities and that they differ from shells in the other set. Continue the questioning until someone makes the observation that two scallop shells, and pairs of shells like them, can fit together. The shells similar to the cowrie shell are made up of one part only.

Materials

Shells, 8 (*Module 4*)
Shells, a large assortment of different kinds
Trays, 2

Activity 3 (Optional)

Arrange on a table the two picture cards of the shells illustrated in figure 4. Ask a small group of children to take real shells and place them around the drawings which they most resemble. Continue this with other groups of children until each child has had an opportunity to match the picture card or drawing with an actual shell in the set.

Materials

Picture cards, 2, of shells (*Module 4*)
Shells, 8 (*Module 4*)
Shells, a large assortment of different kinds

Generalizing Experience

Arrange fruits and vegetables of several different varieties on a table according to some classification criterion such as size, shape, color, or texture (but not kind). Ask the children why these pieces of fruit (and vegetables) can be thought of as being in one set. Change the arrangement and repeat the question. Ask a volunteer to come up and make a different arrangement. Have him then ask the class, "Why have I arranged these pieces of fruit and vegetables here in one set?" The one who first offers a satisfactory answer may rearrange the objects and ask the questions of another child.

Materials

Fruits, an assortment of several different varieties
Vegetables, an assortment of several different varieties

FIGURE 4

APPRAISAL

Ask a group of children to select a set of red objects from familiar items in the classroom. Repeat for other colors and shapes with other groups of children.

Select a set of objects which can be classified as different from another set in (a) color, (b) size, (c) shape, and (d) texture. Include a few shapes cut from different grades of sandpaper to add some new material to the collection. Then ask several children to state the several ways in which the objects could be classified, or divided into groups. The children should be able to classify the objects in a variety of ways, and, in each case, state the basis on which they are classifying.

Materials

Objects, an assortment
Sheets, 3, sandpaper, 1 sheet each of extra fine, medium, and coarse texture (*Module 4*)
Triangles, 3, sandpaper (*Module 3*)

COMPETENCY MEASURE

TASK 1 (Objective 1): Give the child nine paper squares, three squares each of three different sizes. Then tell him, Group the pieces of paper by size. The child will perform the task successfully if he groups the pieces of paper according to the three sizes.

TASK 2 (Objective 2): Give the child the following felt shapes: one red rectangle, one blue rectangle, one yellow triangle, one red triangle, one red square, one blue square, and one red circle. Say, Put these objects in three separate sets so that the objects in each group are the same in some way. The child should construct three separate groups. (He may use color, shape, or other basis which produces three separate groups.)

TASK 3 (Objective 3): After the child has grouped the shapes, say, Tell me, how did you decide what to put in each group? The child will successfully complete this task if he identifies his basis for classification, if the classification he describes is the one he followed, and if the classification creates three separate groups.

Materials

Squares, 9, paper, 3 each of 3 different sizes (small, medium, and large)
Shapes, 7, felt, 1 each of a red rectangle, blue rectangle, yellow triangle, red triangle, red square, blue square, and a red circle (*Module 2*)

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4 Classifying/a

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SCIENCE... A PROCESS APPROACH II

MODULE

5

Observing/c

Temperature

OBJECTIVES

At the end of this module the child should be able to

1. *DISTINGUISH* between two very different temperatures without the aid of a thermometer.
2. *DISTINGUISH* between the temperature in one place and that in another, using a color-coded thermometer.
3. *DISTINGUISH* between the temperature at one time and that at another, using a color-coded thermometer.

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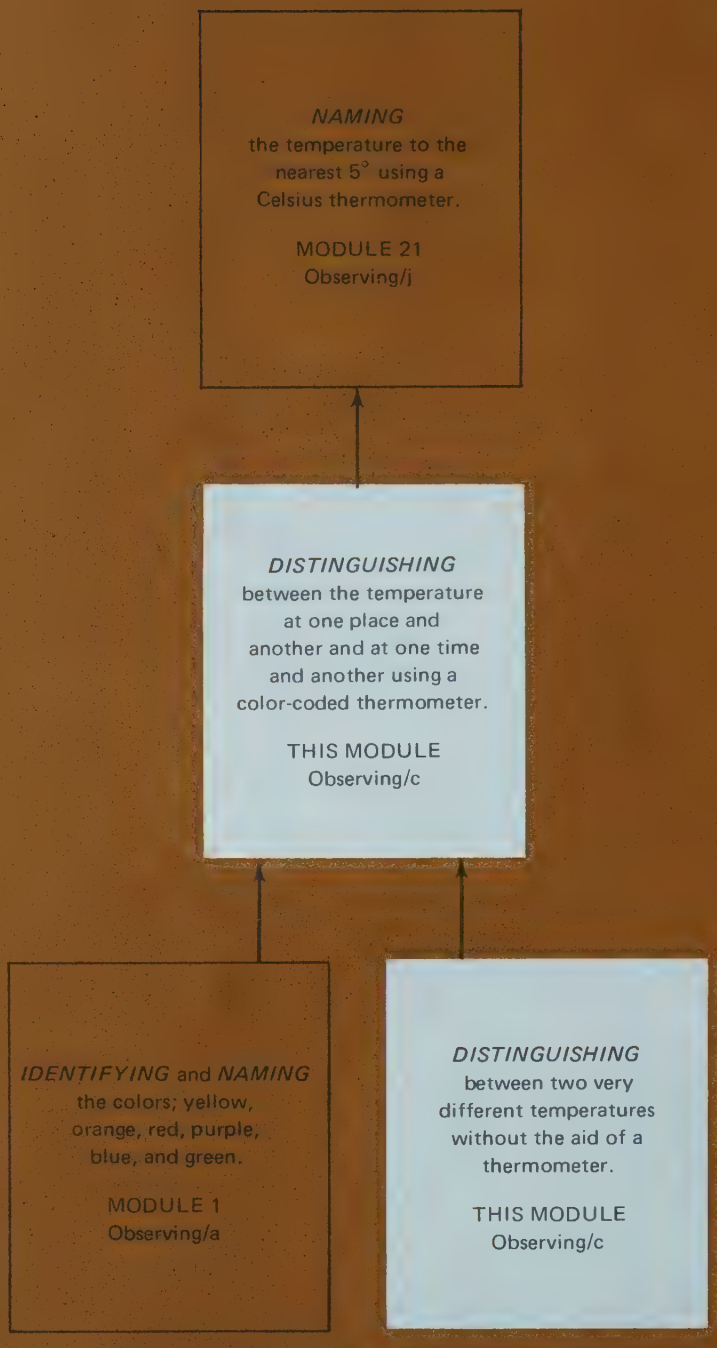
AAAS

SEQUENCE


NAMING
the temperature to the nearest 5° using a Celsius thermometer.
MODULE 21
Observing/j
DISTINGUISHING
between the temperature at one place and another and at one time and another using a color-coded thermometer.
THIS MODULE
Observing/c
IDENTIFYING and *NAMING*
the colors; yellow, orange, red, purple, blue, and green.
MODULE 1
Observing/a
DISTINGUISHING
between two very different temperatures without the aid of a thermometer.
THIS MODULE
Observing/c

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

It is important for young children to learn to use all their senses to make careful observations. It is also important for them to learn that they can use instruments to extend their senses and to make more precise observations.

In this module the children begin by feeling air and water at different temperatures. They then compare temperatures using color-coded thermometers, associating the longer liquid column in the thermometer with warm temperatures. Numerical temperature readings are not necessary for the activities and should be used only if your pupils are mature enough to read numerals.

The activities described here are written for the color-coded thermometer. If you use a different code, you will need to make an appropriate adaptation of the instructions. In geographic regions where temperatures change little, other kinds of adaptations may also be necessary.

Two temperature scales in common use today are the Fahrenheit scale and the Celsius or centigrade scale. The use of the Celsius scale is recommended but not required in the early parts of this program. You may find the background paper on "Measuring Temperature and Heat" in the *Commentary for Teachers* useful.

Children may describe objects as "feeling" warm or cool even though the objects may be at the same temperature. A piece of metal at room temperature may feel cooler than a piece of wood. This difference is due to the different thermal conductivities of the objects—that is, the rate at which heat is conducted away from the hand and through the object. It is probably better not to try to explain at this time the different sensations of "coolness" given by the different objects.

This module has been placed early in the sequence so that weather observing can be carried on throughout the rest of the year. If you feel that the children in your class are not mature enough to carry out the suggested activities at this point, postpone the module for several months.

Vocabulary

thermometer	warm
temperature	cool
warmer	hot
cooler	cold
higher	up
lower	down
earlier	rise
later	fall

INSTRUCTIONAL PROCEDURE

Introduction

You may introduce the topic of temperature in connection with any of a variety of other classroom activities. If the temperature of the outdoor air is cooler than that of the indoor air, the discussion might center around what the children wore to school and how their clothing would be chosen differently if it were warmer or colder outside.

Whether they are inside or outside, the area that children choose to sit or to play may depend on the temperature. Observe whether they choose a sunny or shady area, and in asking them about their choice, encourage them to use the words *warm* or *cool* or *hot* or *cold.*

The children may be very warm after a period of vigorous physical activity or may be cold after exposure to low temperatures outdoors. Ask them how they feel, how their skin feels, and whether they are hot or cold.

You might ask how they or their parents decide if the water in the bathtub or shower is just right for taking a bath. Their suggestions probably will include testing the water with a toe, hand, or elbow. As you discuss what is done when the water is too hot or too cold, encourage the children to describe the difference of the "feel" of the water in terms of *cool, cooler, warm,* and *warmer.* These terms may not mean the same to everyone.

You might introduce this module by asking what the children think of when they hear the word *temperature.* The discussion might be related to any of the situations described above.

Activity 1

Devise a plan to provide two areas where the air temperature will be different. This might be done by opening a window, by using an oven turned low, or by using a heating duct, radiator, or air conditioner. Keep the source of warm or cold air as inconspicuous as possible.

Ask four children at a time to extend their arms from their sides so that one hand will be in the heated or cooled area and the other not. Tell them to wait until all have felt the two areas before they discuss their observations. Unless the differences are great, some of the children may not detect a difference, or they will not agree about which area is the warmer.

Show the children two similar containers with equal amounts of water in them. The water in one container is at room temperature while the water in the other is warmer or cooler by about 10 degrees Celsius. Ask the children what they observe. They may say that the containers and contents look alike.

Have several pairs of containers at the table so each group of three or four children may sample the water. Have one child at a time put one hand in each container. When

they have all sampled the water, call them together to discuss their findings. Ask them to describe any differences. The response should be in terms of *warmer than* and *cooler than.*

Ask the children how they might show in some other way that the water in one container is warmer than that in the other. If no one suggests using a thermometer, bring out one of the coded thermometers and ask the children what it is and what it does. If the children do not know, tell them it is a thermometer and it measures temperature. (See Figure 1.)

As an alternative to the above activity, you may wish to have a number of containers of water of a variety of temperatures placed on a large table. Allow the children to explore them freely—touching, pouring, and mixing the water. Ask what the temperature of the water in the different containers is. Let them talk about their observations and encourage them to try to determine which is the hottest, which is the coldest, and how much hotter or colder one container is than another. You might suggest that they arrange the containers from hottest to coldest.

If they have difficulty describing their comparisons, ask about the thermometers as suggested above and show them the color-coded thermometers.

Materials

Containers, 4, 500-ml, containing hot water and two containing cool water (*Module 6*)
Thermometers, 6, Celsius, ⁻20° to 110°, with color-coded labels (*Module 5*)

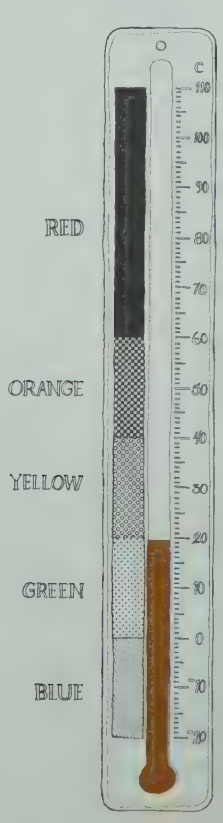

FIGURE 1

Activity 2

Put four large containers of water at different temperatures in front of the children. To help present the coding device, wrap or mark the containers with colored construction paper matching the color code on the thermometer scale. The water in the orange container should be moderately hot (50°C); in the yellow container, warm (30°C); in the green container, cool (10°C); and in the blue container, cold (⁻5°C). You will need an ice and salt mixture in the blue container in order to register a "blue" temperature on the thermometer.

Let the children feel the water in the containers and describe it: hot, cold, and so on. Put the coded thermometer into each container in turn so that the colored liquid in the thermometer will move conspicuously. Be sure each child sees a change in the position of the top of the red column. Describe what you are doing and ask different children to describe what they see. Ask questions such as: When does the red line go up? (When the thermometer is in the hot water.) When does it go down? (When the thermometer is in the cold water.) Why have I put this label on the thermometer? (When the red column of liquid in the thermometer is up to the orange part of the thermometer scale, the water is hot like the water in the orange container; if the red column is only up to the yellow part of the thermometer scale, the water is warm like the water in the yellow container; and so on for the cool water in the green container and the cold water in the blue container.)

Materials

Containers, 4, 500-ml, of equal size (*Module 6*)
Paper, 4 sheets, construction, 1 each of the colors orange, yellow, green, and blue
Thermometers, 4, Celsius, ⁻20° to 110°, with color-coded labels (*Module 5*)
Table salt, 100 g

Activity 3

Ask a child to look at the thermometer and tell you whether the temperature is in the red, orange, yellow, green, or blue area. Tell the children that when they do this, they are "reading the thermometer." If the red column is alongside the yellow part of the thermometer scale, for example, the temperature of the room is "yellow." (See Figure 2.)

Ask the children what color they think they would read on the thermometer if it were placed outdoors. Put the thermometer outdoors and note the reading on the code. Select a colored square to match the color code corresponding to the temperature reading, and paste it over the proper date numeral on a large calendar. Repeat this activity daily at the same time of day. Let the children take turns reading the thermometer and selecting and pasting the appropriate colored square on the calendar. If a large calendar is not available, fasten the colored squares in the form of a calendar to the bulletin board and put the date on each colored square or let the children color in the square on a smaller calendar.

Materials

Thermometers, 6, Celsius, ¯20° to 110°, with color-coded labels (*Module 5*)
Squares, 30 or so, paper, of the colors red, orange, yellow, green, and blue (Depending on where you live, you will need squares of some colors more than others.) (*Module 1*)
Calendar, 1, large

FIGURE 2

Activity 4

(Temperature readings in this activity are to be made outdoors.)

When the children arrive for school, ask one or more of them to read the thermometer. Show the children the *Temperature Chart* and demonstrate how you adjust the ribbon to match a thermometer reading. Ask a child to set the ribbon on one thermometer of the *Temperature Chart* to correspond to the reading the children have just made. At a time as much later in the day as possible, read the thermometer and set the second ribbon thermometer at that temperature. (See Figure 3.) Discuss the change in temperature. Encourage the children to say, "It is warmer than it was this morning" or "It is cooler than it was this noon." The lower the red ribbon, of course, the cooler it is. Have the children make the two daily readings for several days and discuss the temperature changes.

Materials

Thermometer, 1, Celsius, ¯20° to 110°, with color-coded labels (*Module 5*)
Temperature Charts, 3, adjustable (*Module 5*)

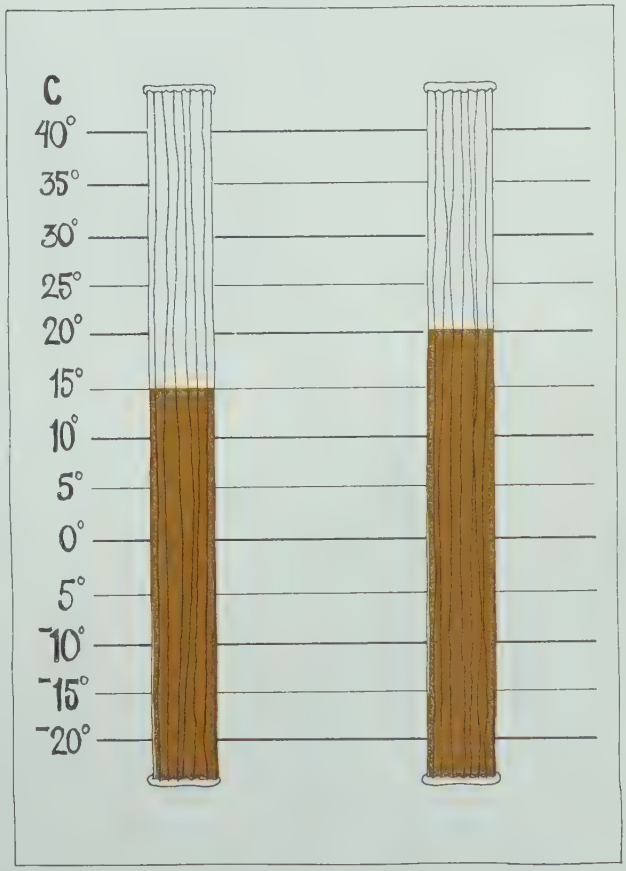

FIGURE 3

Activity 5 (Optional)

The children may be interested in pursuing the study of weather conditions other than temperature. If so, a record of cloud cover, wind, precipitation, or all of these may be kept. The illustration here shows one device for comparing cloud cover from day to day. (See Figure 4.)

Other devices could be made in the same manner for wind and for precipitation.

Materials

Paper, 1 package, construction
Pins, 1 box, straight or push

Generalizing Experience

Give each child a small cup of fruit juice which is colder than room temperature by about 10 degrees Celsius. Or, use cartons of milk if they are distributed. Save a small portion for testing. Suggest that they drink some of the juice if they wish. Then ask questions such as: Is it cold or hot? How hot or how cold? Is it cooler or warmer than water from the drinking fountain? How can we find out? (Use a thermometer to find the temperature of the water from the drinking fountain and of the fruit juice.)

As an alternate generalizing experience you might try preparing hot chocolate for the children. An interesting test is to determine at what temperature the hot chocolate is just right for drinking. Where on the color scale should the red column of the thermometer be?

Materials

Juice or milk in containers, enough for all the children
Thermometer, 6, Celsius, $^{-}20^{\circ}$ to 110°, with color-coded labels (*Module 5*)

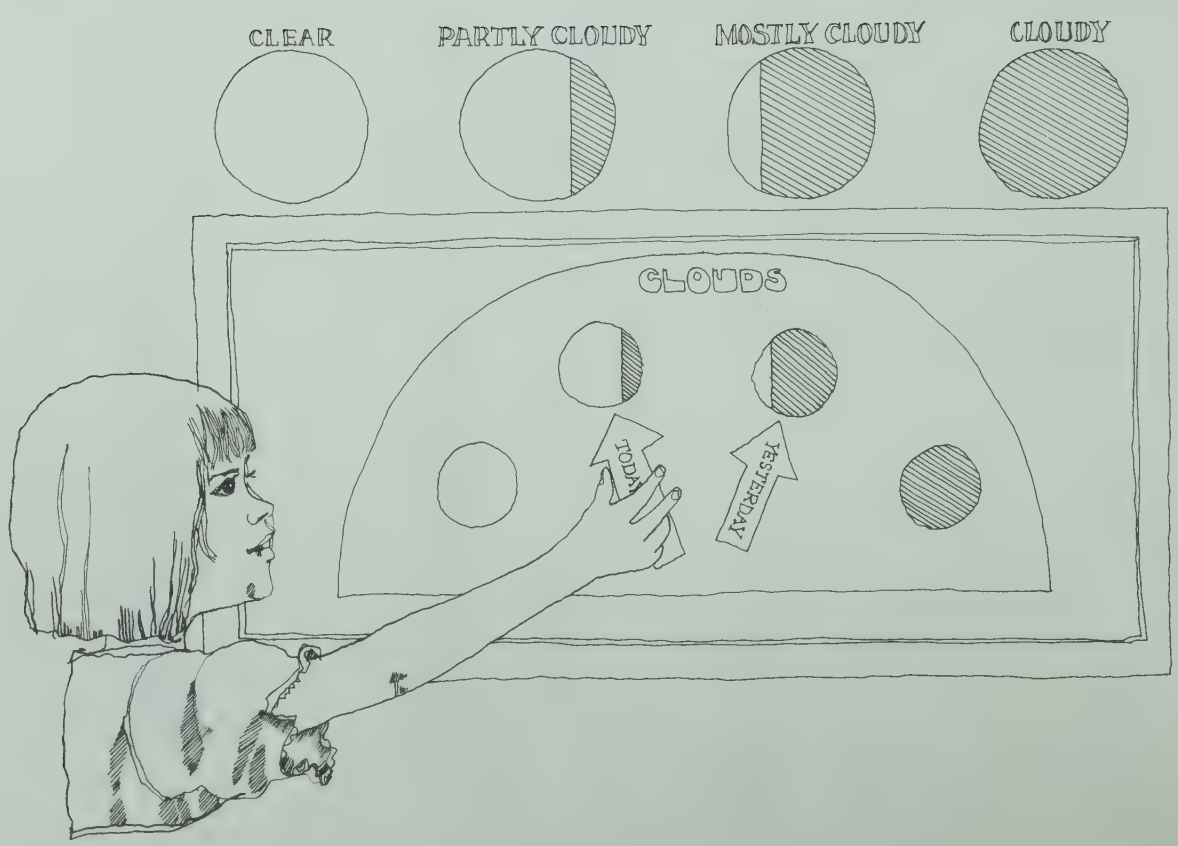

FIGURE 4

APPRAISAL

Put an incandescent desk lamp on a desk and turn it on. The bulb should be close enough to make a noticeable difference in the temperature of the desk top. Ask the children to feel the desk in various places and determine where it is "warmer" and where it is "cooler." Someone will probably suggest placing a thermometer in various places on the desk and taking the reading. If not, ask the children how they could find this out.

Ask them to use the thermometers to find where it is "warmer" and where it is "cooler." Determine whether or not their findings with the thermometers agree with their findings when they used their hands to feel the desk.

Have the children put a thermometer in the warmest place and note the temperature. Then turn the light off. After about five minutes, ask them to look at the thermometer again. Ask them if the place is warmer or cooler than it was when the lamp was on.

Materials

Lamp, 1, incandescent, 60- to 100-watt
Thermometer, 6, Celsius, ¯20° to 110°, with color-coded labels (*Module 5*)

COMPETENCY MEASURE

Show each child three containers of water. Color the water in two of the containers with food coloring so that one contains blue water and the other red. Let the blue water be the warmest, the uncolored water be of intermediate temperature, and the red water the coolest. The difference in temperature between the warmest and the coolest should be at least 20° Celsius.

TASK 1 (Objective 1): Have the child place one finger in the blue water and one finger in the red water. Now ask, **Which is warmer?** The child should say that the blue water is warmer.

TASK 2 (Objective 2): Put one thermometer in the uncolored water and one in the red water. After about half a minute, look at the thermometers and say to the child, **Look at the thermometers and tell me which water is warmer.** The child should state that the uncolored water is warmer.

TASK 3 (Objective 3): Show the child a color-coded thermometer that is at room temperature. Say, **See the temperature measured by the thermometer.** With the child watching, place a few drops of alcohol on the bulb of the thermometer. Wait a few moments and then ask, **Is the temperature on the thermometer the same as it was before or is it higher or is it lower?** The child should give an indication that the temperature is lower (even though the temperature may have remained within the same color range).

Materials

Containers, 3, 500-ml, clear plastic, full of water (*Module 6*)
Food coloring, 2 containers, 1 red and 1 blue (*Module 5*)
Thermometer, 2, Celsius, ¯20° to 110°, with color-coded labels (*Module 5*)
Alcohol, 1 small bottle, with dropper

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5 Observing/c

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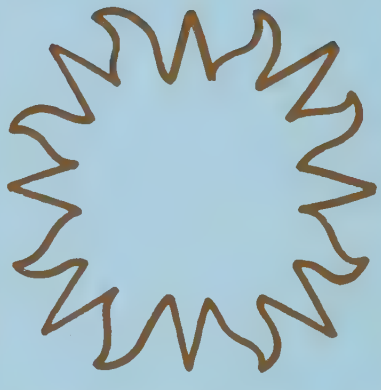

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MODULE

6

Using Space/Time Relationships/b

Direction and Movement

OBJECTIVES

At the end of this module the child should be able to

1. *IDENTIFY* objects that are moving or not moving.
2. *DEMONSTRATE* movements up, down, forward, back, right, and left.
3. *NAME* the direction in which other children, animals, or objects are moving using the words *up, down, forward, back, right,* and *left.*

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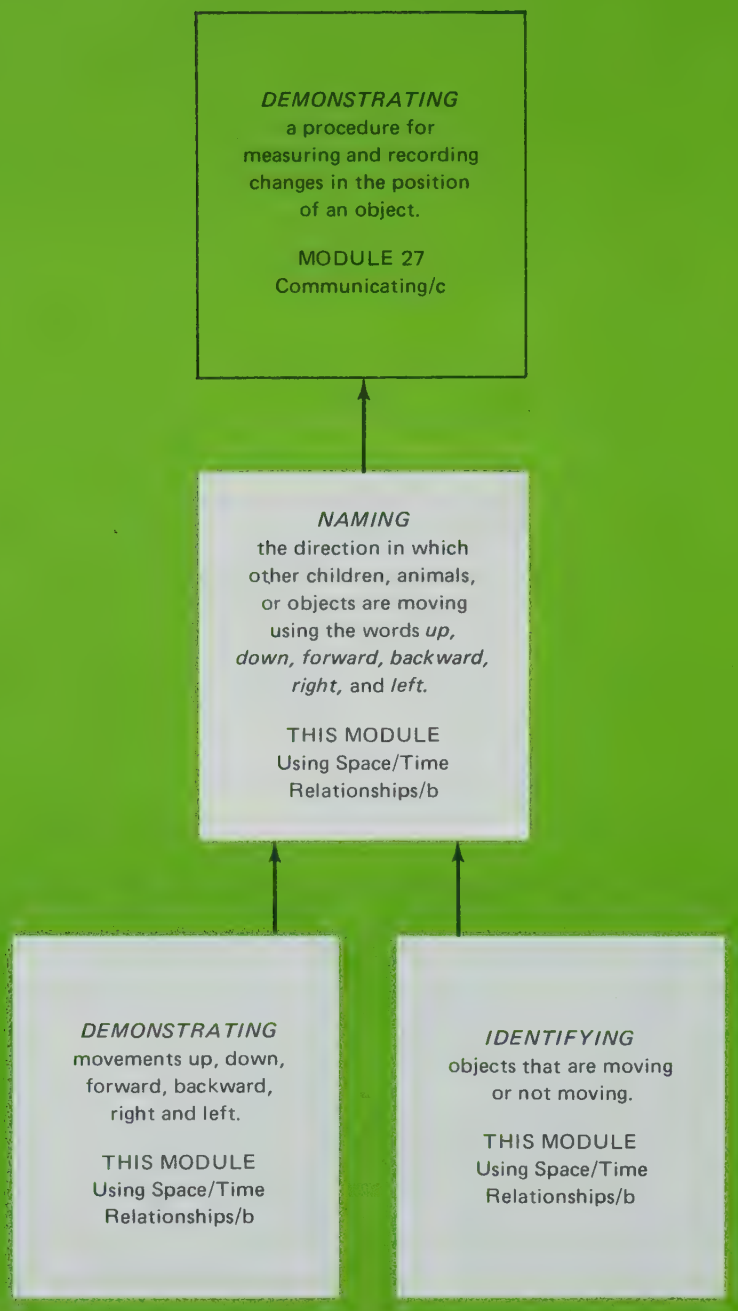
SEQUENCE


DEMONSTRATING
a procedure for measuring and recording changes in the position of an object.
MODULE 27
Communicating/c
NAMING
the direction in which other children, animals, or objects are moving using the words *up, down, forward, backward, right,* and *left.*
THIS MODULE
Using Space/Time Relationships/b
DEMONSTRATING
movements up, down, forward, backward, right and left.
THIS MODULE
Using Space/Time Relationships/b
IDENTIFYING
objects that are moving or not moving.
THIS MODULE
Using Space/Time Relationships/b

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the Program Guide available on request from Ginn and Company: Lexington, Massachusetts 02173

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RATIONALE

The children have had experience in recognizing and using shapes, in observing their surroundings with several senses, and in describing their observations. This module continues this skill development by having the children observe changes in their surroundings, particularly changes in position. They are given many opportunities inside and outside of the classroom to observe movement. They will observe movement of both living and nonliving things. As they search for words to describe what they see, they are introduced to the direction words *up, down, forward, back, right,* and *left.*

Observing and describing movement can also be taught during a walk, a field trip, recess, or play activities. Use your own judgment in selecting from among the activities described here and from normal classroom situations those experiences that will most effectively help the children to learn to observe and describe movement.

After learning about change in position (movement), the children will observe changes in color and changes in phase from solid to liquid in *Change, Observing g, Module 17.* The concept of change is the common thread between these modules. The concept of direction and the use of the arrow symbol to represent direction are also important in the present module. These ideas provide a basis for an introduction to vectors and mapping in later modules.

In *Activity 4* three games are presented. After you have given two or more children the materials and instruction for the games, the games can become auto-instructional or instructional for pairs of children. As soon as a few children know the "rules" of the games, they can teach others. Although the games are given as *Activity 4,* they should be introduced to some of the children on the day this module is first taught. Then individuals or pairs of children can be playing the games as other activities are being taught. These games should be especially helpful for those who have difficulty with the direction words.

Activities 5 and *6* are marked "Optional." Some classes will need these additional experiences and others will not. Furthermore these activities can be taught later in the year if that seems appropriate for your children. The first four activities as well as these last two provide a number of choices for the teaching of this module.

(Note: In the trial testing of this module, many teachers found a wide range in the ability of the children to use direction words. Where needed, the teachers used simple practice activities and games to help the children develop competence in this skill. They had to work frequently with individual children during the entire year.)

Vocabulary

direction	back
movement	forward
arrow	right
up	left
down	

INSTRUCTIONAL PROCEDURE

Introduction

As the children watch, put five or six mothballs in a large, transparent container of water to which you have added about 15 grams of baking soda and an amount of vinegar determined previously by trial. The mothballs will sink to the bottom of the container. Then bubbles will form on the balls causing them to rise to the surface of the water. When the bubbles become detached at the surface, each ball will again sink to the bottom of the container where it will acquire more bubbles and rise again. When the action slows, start it again, if you wish, by adding more vinegar or more baking soda, depending on which substance has been "used up."

If the children are sufficiently intrigued, let some of them help you set up several smaller demonstration containers for other places in the room where they can observe the action at close range. *Caution: Since mothballs are dangerous if swallowed, do not let the children handle them.*

Ask the children to describe what they see. They should mention the *up* and *down* motion. Tell the children that they have observed *change* and that the movement of an object is a kind of change. Things can move in many ways and they can describe the movement by telling if the object moved up or down, or forward or back, or right or left, or around.

As you talk with the children about what they observed, stress the notions of movement and direction and the two directions, *up* and *down*. Put a paper arrow on the board with masking tape. Ask the children to show with their hands the direction of the arrow tip and to name that direction. (See Figure 1.)

Materials

Mothballs, 1 box, naphthalene
Baking soda, 1 container (*Module 6*)
Vinegar, 1 bottle, white (*Module 6*)
Container, 1, transparent, 1-liter or larger
Containers, 4, 500-ml, clear plastic (*Module 6*)
Arrow, 1, paper, large
Tape, 1 roll, masking

Activity 1

Play the familiar game of "Red Light–Green Light" in which the children are allowed to move in whatever way has been established as long as the leader has not spoken the command word, *Red Light*. If the leader detects movement after he says the command word *Red Light* and before he gives the command *Green Light*, he then directs any child he has "caught" to return to the starting line.

Talk about the game with the children and relate the activity to the concepts of movement and direction by using the words *forward* and *back*.

Activity 2

For an additional movement activity, have the children stand in some orderly array in which they all face the same direction. Leave enough space between children so that they can walk forward and back without collisions. Then direct the children to move forward and back by commands such as: Take one large step forward. Take two small steps back and three small steps forward.

A series of such instructions should help to develop a feeling for direction, as well as for distance moved in a certain direction.

Play the familiar game of "Simon Says" with the children. "Simon" can give the children practice in applying the concept of direction by asking the children to look or point in some direction. Let the children take turns leading the game.

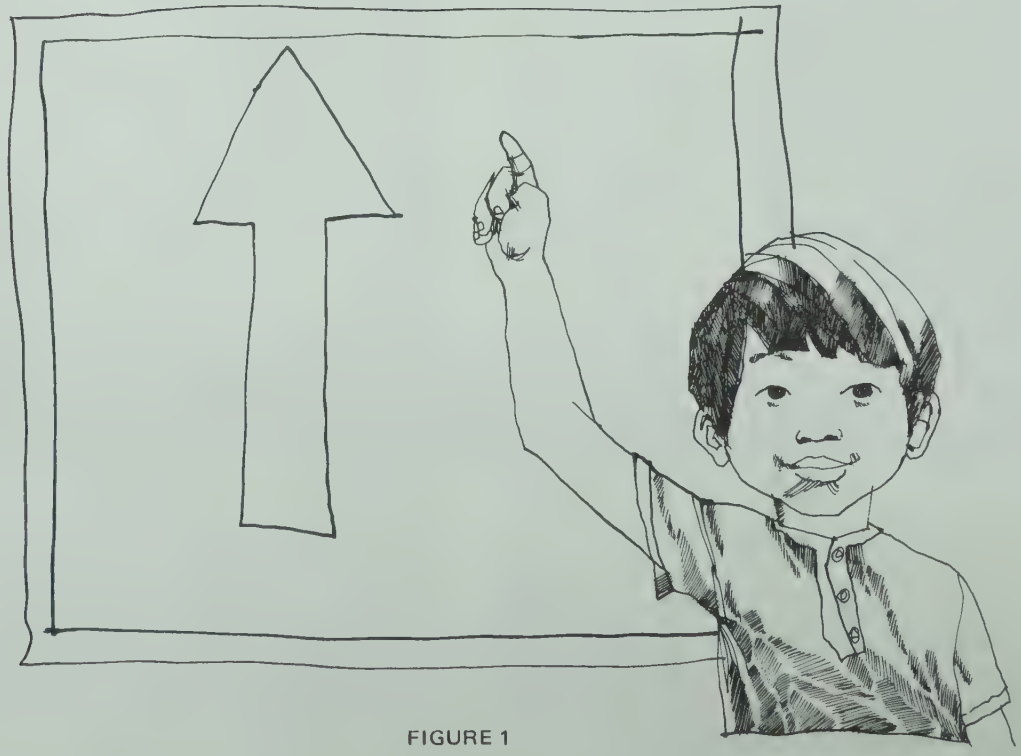

FIGURE 1

Activity 3

Have one child come forward, and with his back to the other children, identify his own right hand so all can see. Ask all children to hold up their right hands. Repeat with the left hand. Tell the child to wave with his right hand and then his left. Have the others do the same.

Have the children tell you in which direction they should read across a bulletin board or a page of a book. Put a picture of a kitten on the left side of the flannel board and a picture of a saucer of milk on the right side (or other pairs of related pictures). Connect the two pictures with a piece of yarn. Have a child trace the path from the picture at the left to the corresponding picture at the right. Thus the child demonstrates the process of reading from left to right as well as the relationship of the left hand to the left side of the flannel board.

Here are some other suggestions for activities using the concept of direction:

1. Ask the children to salute the flag with their right hands.

2. With the children's help, sort objects, such as right and left shoes and mittens.

3. Let the children pretend that they are cars, or let them play with toy cars—driving on the right side of the street, turning right, turning left, going forward, going back.

Review direction and distance by having the children follow instructions such as: Take two large steps forward; now take three steps to the right. Let the children take turns giving instructions.

You may find it helpful to use paper arrows or arrows drawn on the chalkboard to represent the number of steps in a given direction: → → → → for four steps to the right; ← ← for two steps to the left.

Materials

Board, 1, flannel
Pictures, 2 or 3 pairs, of related objects such as a kitten and a saucer of milk
Yarn, 1 piece, about 1 meter long
Objects, 2 or 3 pairs, left-right pairs, such as shoes and mittens
Arrows, 4-6, paper (optional)

Activity 4

Use the following three games to provide practice for those children who need it to identify the directions *right, left, up,* and *down*. The *R&L* game focuses on the directions *right* and *left* only, and *Ups 'n' Downs* on those two directions only. The third game, *Helicopter,* provides experience with all four directions at one time. All of the games can be played by individuals or by pairs of children.

1. R&L

This game consists of a maze with the clues *R* (right), *L* (left), and ← (forward) at important intersections. You might wish to give instructions by telling the following story:

"It is time for the children in this school (designate the building at the lower right corner of the maze) to go home, but the bus driver, Mr. Kane, does not know the way to the school bus stop (designate the bus stop shown at the upper right corner of the maze). See if you can help Mr. Kane get the children to the school bus stop. (Put the toy bus at the school building and head it in the proper direction.) Do you see the red letters *R* and *L* and the red arrows? They are clues for you to help Mr. Kane find his way. *R* means right. *L* means left. The arrow means forward. You know what those words mean. If you get to a dead end, go back to the last red mark (R, L, ←) you drove to, and try again."

Materials

R&L game, 3, each consisting of a game board and a bus (*Module 6*)

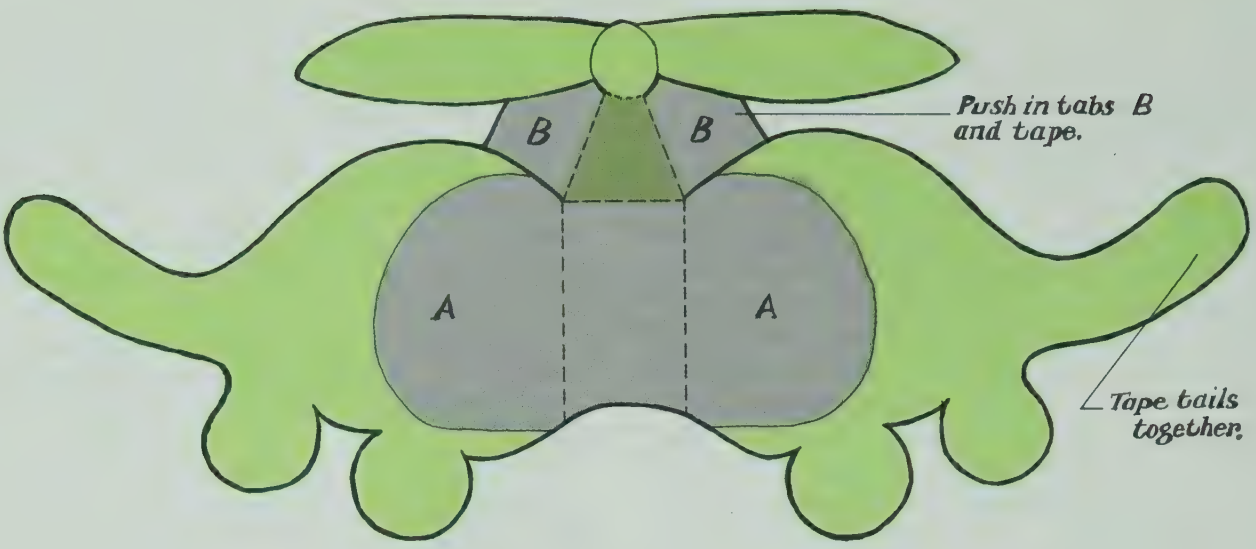

FIGURE 2

2. Ups 'n' Downs

Hang on a door a strip of adding machine paper from the top of the door to the bottom. Starting from the floor, make horizontal marks on the paper 20 centimeters apart. Tie a paper clip to a ruler, making sure the string will not slip off the ruler. Then tape the ruler to the top of the door in a horizontal position. Be sure the ruler is firmly attached. The paper clip should hang just in front of the adding machine paper, but far enough from the door to give the helicopter clearance.

Next trace the helicopter form (Figure 2) on a piece of cardboard. Cut out the helicopter (on the heavy lines) and assemble (fold on dotted lines). Tape two small washers to the inside of the cardboard helicopter at *a* to give it additional weight.

Now, loop a long string through the paper clip (see Figure 3) and attach the helicopter to one end of the string so that it hangs vertically in front of the paper with the horizontal marks. Place a book over the other end of the string about three meters from the wall (see Figure 3). The book will hold the string, and the child can pull the string from either side of the book to make the helicopter go up and down. Place the spinners next to the book.

Ask the child to sit on the floor next to the book and spinners. Tell him that the book and spinners are the control panel of the helicopter. Use an explanation like this:

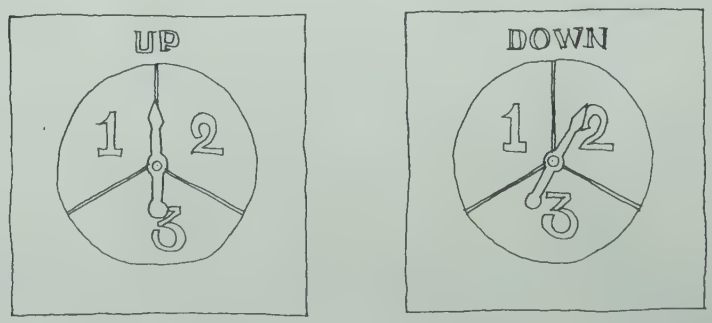

FIGURE 4

"When you pull the string this way (demonstrate), the helicopter will go up. When you pull the string this way (demonstrate), the helicopter will go down. See these two spinners? (See Figure 4.) One has the word *UP* on it. When you spin this spinner, you pull the string to make the helicopter go up. The other spinner has the word *DOWN* on it. When you spin this spinner, you pull the string the other way to make the helicopter go down. See the marks on the long paper? When you spin a spinner, you move the helicopter the number of marks indicated."

Demonstrate the use of the spinners and the paper strip until the child understands, and then let him begin. Tell the child that if he spins a number on either spinner that would take him beyond the end of the marks on the paper, he has to let someone else play.

Materials

Tape, 1 roll, masking
Paper, 1 roll, adding machine (*Module 6*)
Pen, 1, marking
Paper clip, 1
Ruler, 1
Helicopter, 1 (See Figure 2 for construction directions.)
Cardboard, 1 piece, heavy
String, 1 ball (*Module 6*)
Spinners, 2 (*Module 6*)
(Note: Mark off each spinner into 3 sections and label each spinner as shown in Figure 4.)
Washers, 2, small (*Module 6*)
Book, 1, to hold string

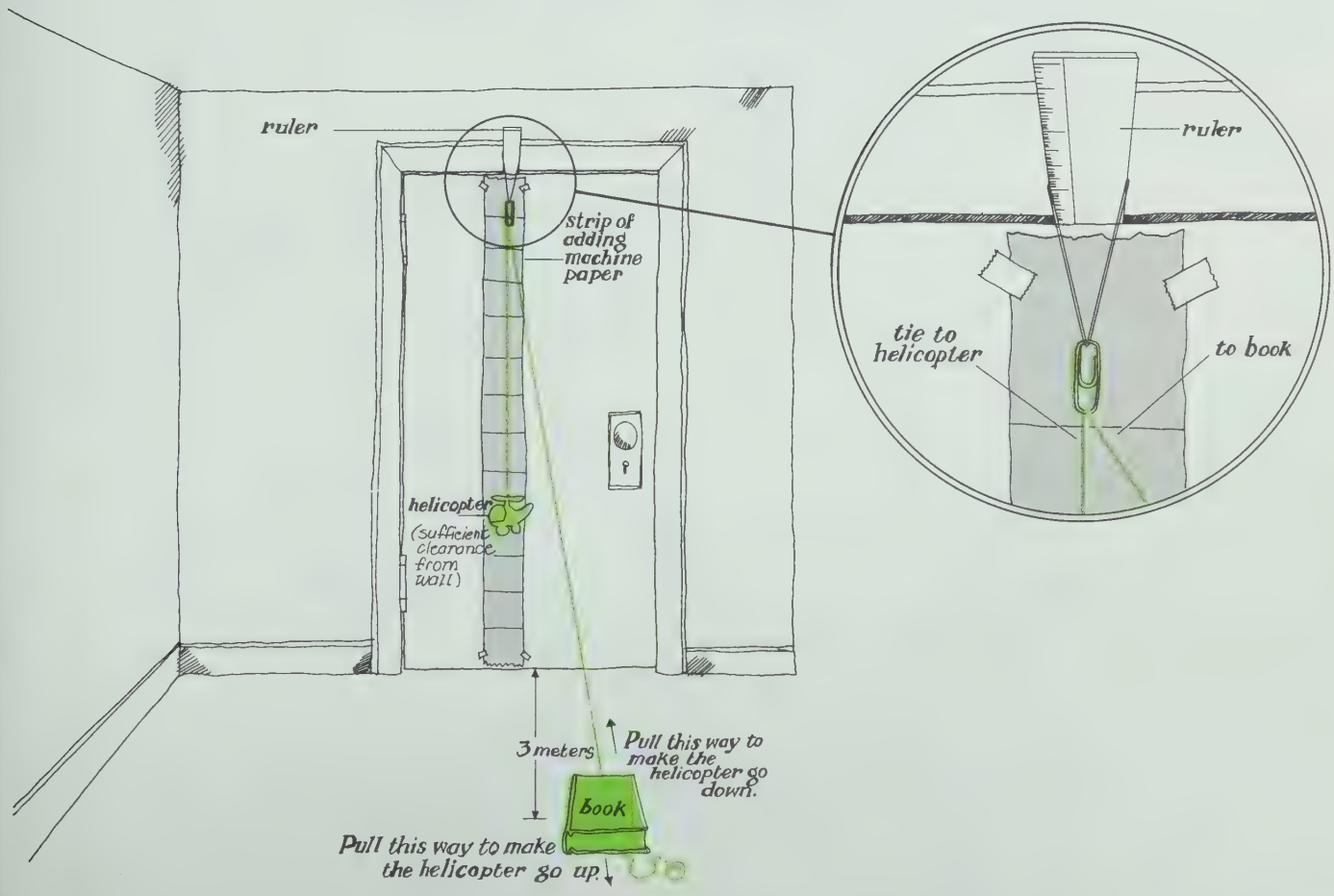

FIGURE 3

3. Helicopter

The two previous games dealt with exercising the child's use of the terms *right* and *left* (*R&L*), and *up* and *down* (*Ups 'n' Downs*). *Helicopter* is designed to exercise all four of these terms at one time.

The illustrations will help you set up the *Helicopter* apparatus. Figure 5 is a side view of the completed apparatus. The spring clamps are holding the two metersticks together. Figure 6 shows how the two metersticks and six washers are arranged. The washers lie between the two metersticks. The spring clamps are not shown. Figure 7 shows a side view of the apparatus with one of the metersticks removed. The numbered circles designate the positioning of the washers between the metersticks. Figure 8 shows the completely assembled *Helicopter* apparatus ready for use.

The following is a set of step-by-step instructions for the assembly of the *Helicopter* apparatus.

1. Place two small washers at point *1*, Figure 7. Note that the washers are on the bottom edge of the metersticks. Place a spring clamp over the metersticks at point *1* as in Figure 5.

2. Place two small washers at point *2*, Figure 7. Note that the washers are at the top edge of the metersticks. Place a spring clamp over the metersticks at point *2* as in Figure 5.

3. Place two small washers at point *3*, Figure 7. Note that the washers are at the bottom edge of the metersticks. Place a spring clamp over the metersticks at point *3* as in Figure 5.

4. Cut a one-meter length of string. Tie the three large washers to one end of the string. Thread the other end of the string (string *a*, Figure 7) between the two metersticks and over the washers at point *1*, Figure 7, and tie it to the end of a paper clip.

5. Cut a four-meter length of string. Thread one end of the string (string *c*, Figure 7) between the metersticks and over the washers at point *3* and under the washers at point *2*, Figure 7, and tie it to the other end of the paper clip.

6. Tape the apparatus over the doorway (Figure 8).

7. Cut a four-meter length of string. Thread it (string *b*, Figure 7) through the paper clip. Tie the helicopter to one end of string *b*. You may wish to use the helicopter you made for the game *Ups 'n' Downs* or you may need to make another helicopter.

8. Put a book over the loose ends of strings *b* and *c* as shown in Figure 8.

9. Completely cover the door with paper (newsprint), and mark the paper with a 20-centimeter grid. The *Helicopter* apparatus should now look exactly like Figure 8.

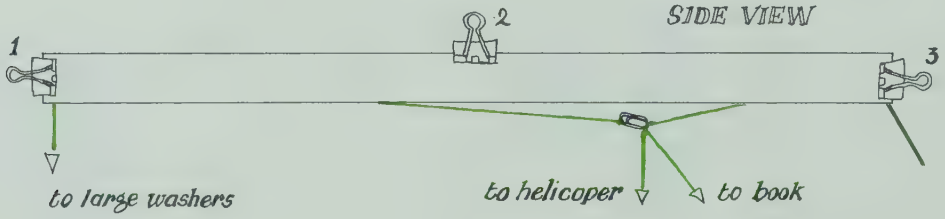

FIGURE 5

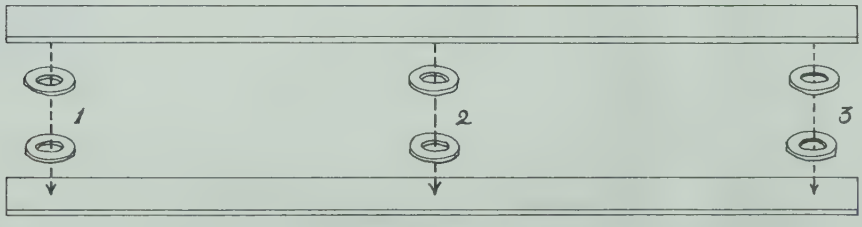

FIGURE 6

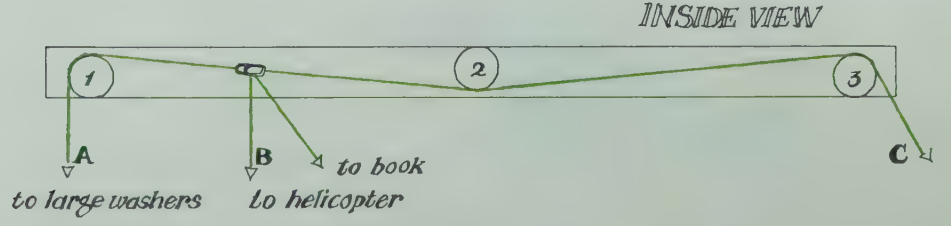

FIGURE 7

You may wish to give the child instructions by reading the following dialogue to him.

"I'm going to show you how to fly the helicopter. Sit here behind the control panel. These are the controls of the helicopter. When you pull string *b*, the helicopter will go up. When you pull string *b* the other way, the helicopter will go down (demonstrate). When you pull string *c*, the helicopter will go right. When you pull string *c* the other way, the helicopter will go left (demonstrate). When you want to go up, use this spinner. See the arrow pointing up? When you want to go down, use this spinner. See the arrow pointing down? When you want to go left, use this spinner. See the arrow pointing left? When you want to go right, use this spinner. See the arrow pointing right? See the lines on the paper? If the spinner's arrow points to *3*, move the helicopter 3 spaces."

Demonstrate the use of the spinners and the grid until you feel the child understands, and then let the child begin. If the child spins a number that moves the helicopter off the grid in any direction, he has to let someone else play.

Materials

Tape, 1 roll, masking
Paper clips, 1
Helicopter, 1 (See Figure 2 for construction directions.)
Cardboard, 1 piece, heavy
String, 1 ball (*Module 6*)
Book, 1, to hold string
Spinners, 4 (*Module 6*)

(Note: Mark off and label each of 4 spinners as shown in Figure 9. On each spinner, draw and color an arrow pointing in the proper direction as in Figure 9.)

Metersticks or measuring sticks, 2
Washers, 11, 8 small, 3 large (*Module 6*)
Clamps, 3, spring
Paper, enough to cover a door

Activity 5 (Optional)

Give each child a paper streamer and take the children for a walk in the school yard on a windy day. If possible, select an open space where the children are facing the school flag in such a way that the flag is flying to the left or right of the flag pole. A small portable flag placed in a convenient location is an acceptable substitute.

Ask the children to face you (your back is to the flag), and to stand far enough apart so that their streamers will not get in each other's way. Tell the children to hold one end of the streamer out in front of them.

Ask the children in which direction the streamers are pointing and if they are all pointing the same way. Have them look at the flag and ask them if it is pointing that way too.

Walk with the children to a position on the other side of the flag. Stand so the children are facing you and the flag. Suggest again that they hold the streamers out as they did before and ask them in which direction the streamers are pointing. With reference to the children, it will be opposite to the direction in which the streamers pointed before. Ask them if the flag is blowing in the same direction as the streamers. Some children may make reference to the change from left to right and the reason for it. If this happens, recognize the validity of the observation, but do not impose the idea on all the children.

Ask the children to look about to find whether they can observe anything else which is moving. Leaves may be blowing, tree branches may be moving, people may be walking, or clouds may be visible and moving.

Materials

Streamers, 1 for each child, paper, cut from adding machine roll (*Module 6*)

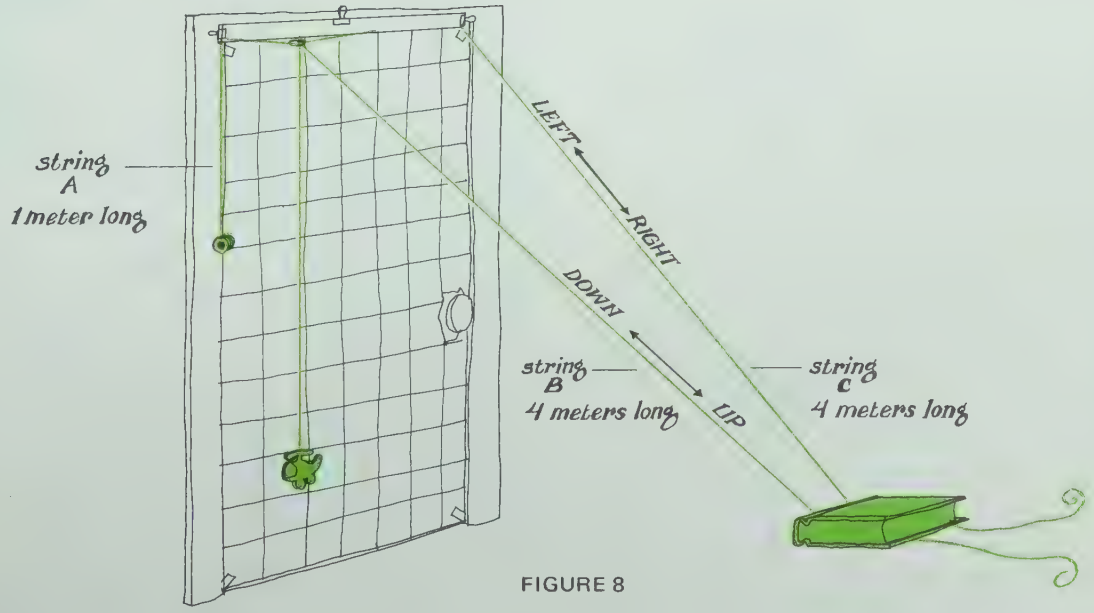

FIGURE 8

Activity 6 (Optional)

A. Put a bowl containing a fish in the room. Place the bowl so that the children can see it easily. Draw the children's attention to the fish by asking questions such as:

Is the fish moving?

In which direction is it moving: Up or down? To the left or right?

Does it always go in the same direction?

Is any part of the fish making a motion?

The children may observe the fin movement, gulping mouth, and movement of the gill cover. If so, describe these movements in terms which the children will find useful. (See Figure 10.)

B. Bring at least one additional animal into the schoolroom. A hamster or gerbil might be good. Tell the children to observe it carefully and to tell you when they see it move. Ask questions such as:

In which direction is the movement?

Does it go straight, or did it turn a corner?

Did it go forward, back, to the left, right, or up and down?

Do you see any movements of its mouth and eyes?

Children who stand in one position may observe the hamster or gerbil differently from those in another position. Recognize and give credit to any child who observes accurately from his own position.

Materials

Bowl, 1, for a fish
Fish, 1, goldfish, guppy, or some other kind
Hamster or gerbil, 1, or another small animal
Cage, 1, for hamster or gerbil

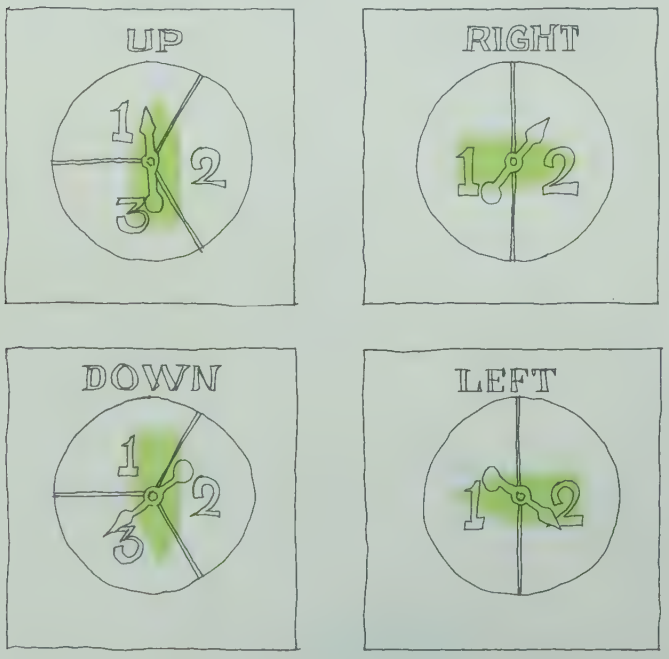

FIGURE 9

Generalizing Experience

Review directions by going on a treasure hunt, fox and goose chase, or some variation of these games. Using chalk, white tempera paint, or paper arrows, mark out a trail around the school ground or neighborhood. The children can follow the course to reach some objective. If possible, divide the group, one group going ahead and leaving a trail of arrows for the other group to follow.

Use toys such as balls and yo-yos to give the children practice in describing up-down directions.

Bring to class a windup toy which demonstrates movement in several directions. Start the toy operating and ask the children to observe all they can about its movements and the different directions of motion.

Materials

Chalk, several pieces (or white tempera paint or paper arrows)
Toys, such as balls and yo-yos
Toy, 1, windup (*Module 6*)

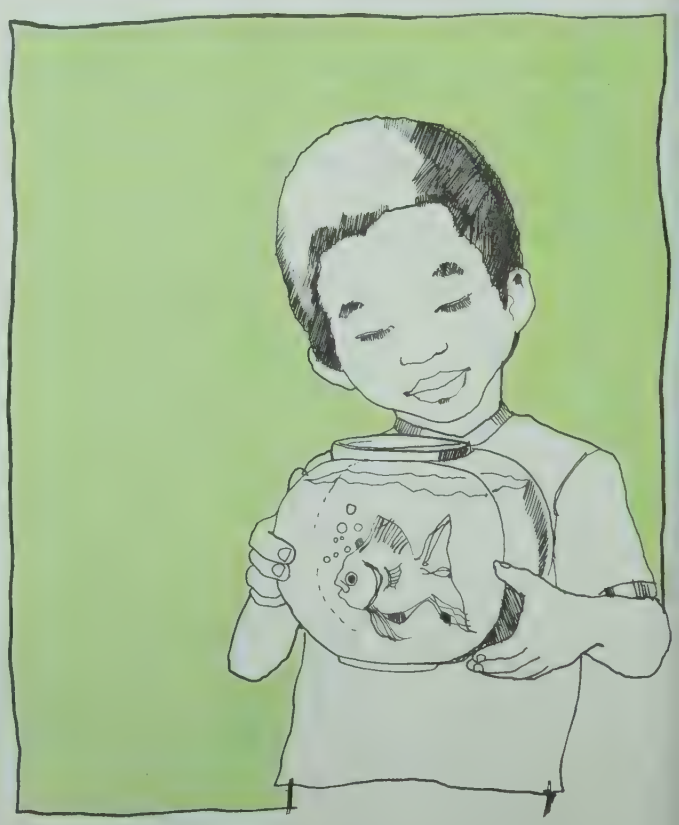

FIGURE 10

APPRAISAL

Invite an older child—perhaps a brother or sister of one of the children—to come to the class for a brief period of time. Tell him that you would like him to stand in front of the class with his back to them, and to point slowly, first with one hand and then the other, to the left, right, and up and down. Then tell him to walk forward and back, and to the left and right. As he slowly does these things, call on children to describe what he is doing. Call first on children who were noticeably active in the *Generalizing Experience.* Invite the older child to turn around and to tell the children his name and grade level. Then let the class describe the movements which they have observed as the older child talked. Observe those children who have not responded actively before.

COMPETENCY MEASURE

TASK 1 (Objective 1): Place two small magnetic compasses about 30 centimeters apart on a nonmagnetic table. Hold a nail or other steel object in one hand and place your hands under the table, one directly beneath each of the compasses. As you move your hands slightly from side to side, the compass needle over the hand holding the steel object will move; the other compass needle should not move. Say to the child, On the table in front of you are two round things with arrows inside. Point to the one that is moving. The child should identify the moving compass needle.

Give the child each of the following oral instructions. Repeat the instruction once if necessary. Allow him a few seconds to respond and then go on to the next instruction.

TASK 2 (Objective 2): Raise your right hand.

TASK 3 (Objective 2): Take three steps back.

TASK 4 (Objective 2): Point up.

TASK 5 (Objective 2): Raise your left hand.

TASK 6 (Objective 2): Point down.

TASK 7 (Objective 2): Move your left foot forward.

The child will successfully complete each task if he follows the instructions correctly.

TASK 8 (Objective 3): Sit facing the child across a table. Place a ball in the center of the table and push it to your right (the child's left). Ask, In which direction is the ball moving? The child should say "left." If he points, ask him to describe the direction in words.

TASK 9 (Objective 3): Drop the ball on the table and allow it to bounce back in your hand. Say, Watch the ball. First it goes in one direction, then in another. In what direction did it go first, and in what direction next? Watch again. Bounce the ball once more. The child should answer "down" and "up" in that order.

TASK 10 (Objective 3): Say to the child, What movement am I making now? Move forward and then back. The child should describe the movement correctly for an acceptable answer.

Materials

Compasses, 2, magnetic, small (*Module 6*)
Nail, 1, or other steel object (*Module 8*)
Ball, 1, rubber (*Module 9*)

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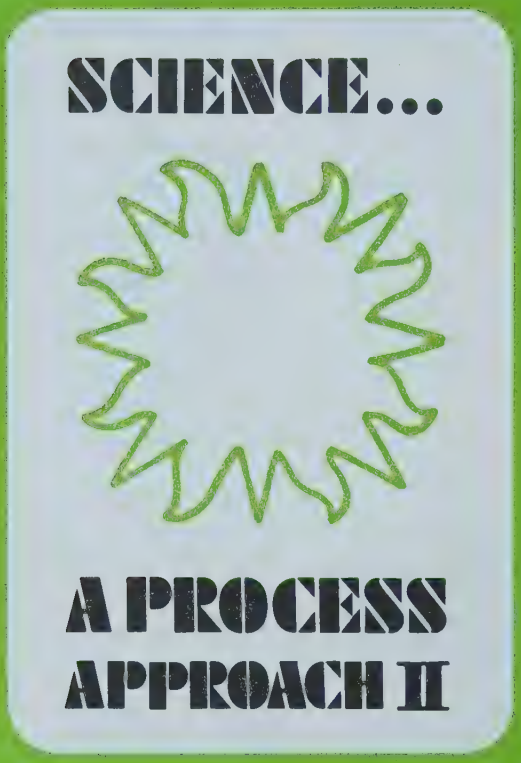
6 Using Space/Time Relationships/b



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SCIENCE... A PROCESS APPROACH II

MODULE

7

Observing/d

Perception of Taste

OBJECTIVES

At the end of this module the child should be able to

1. *DISTINGUISH* between certain food tastes as similar to, or different from, each other.
2. *IDENTIFY* tastes that are sweet, sour, or salty.
3. *NAME* tastes that are sweet, sour, or salty.

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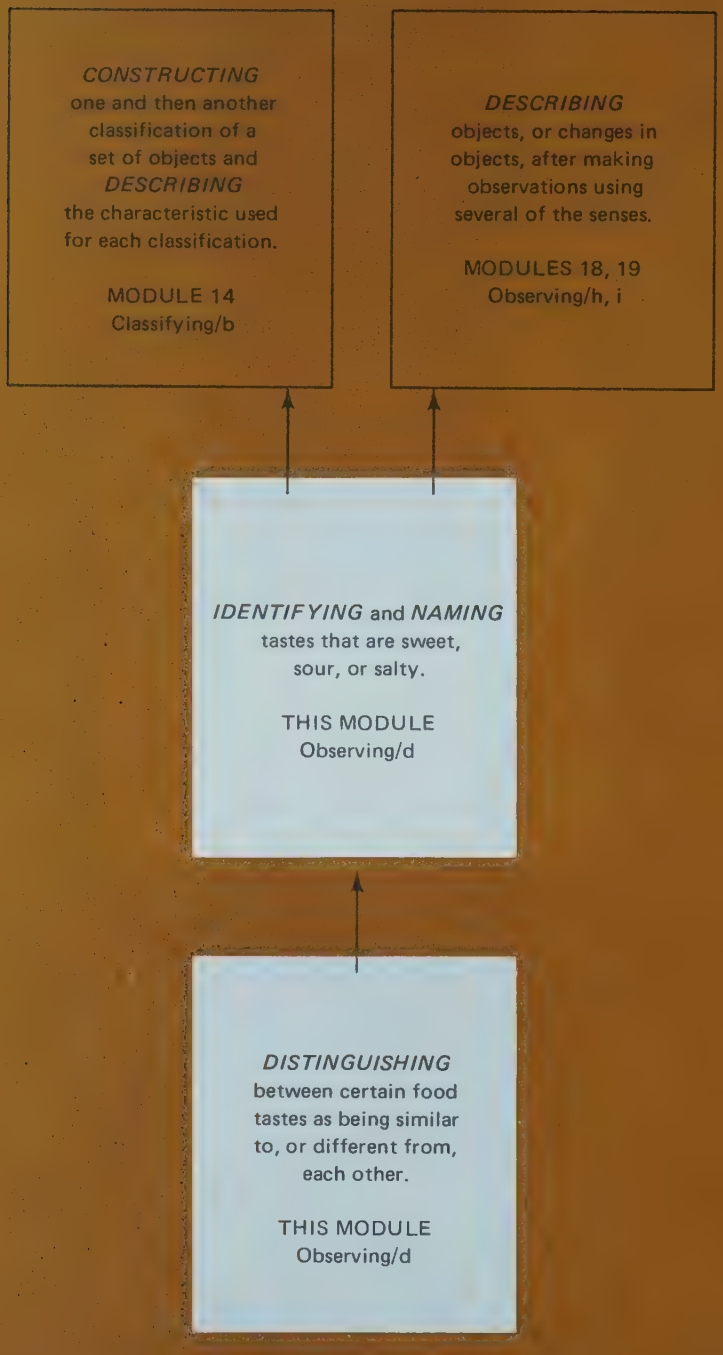
SEQUENCE


CONSTRUCTING
one and then another classification of a set of objects and *DESCRIBING* the characteristic used for each classification.
MODULE 14
Classifying/b
DESCRIBING
objects, or changes in objects, after making observations using several of the senses.
MODULES 18, 19
Observing/h, i
IDENTIFYING and *NAMING*
tastes that are sweet, sour, or salty.
THIS MODULE
Observing/d
DISTINGUISHING
between certain food tastes as being similar to, or different from, each other.
THIS MODULE
Observing/d

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

In previous modules the children have developed their observing skill by using the senses of sight and touch. The sense of taste is introduced here (only in relation to food substances) to add to the sources of direct sensory descriptions of things. In later modules the children learn to use their senses of hearing and smelling to make observations.

Three of the four basic tastes are explored: sweet, sour, and salty. Bitter tastes are not introduced here because young children usually will not tolerate them. Taste observations should be used only to describe familiar substances. Emphasize that it is not safe to taste unfamiliar things.

Vocabulary

taste	sour
sweet	salty

INSTRUCTIONAL PROCEDURE

Introduction

Show the children a lemon and ask what they can tell you about it. They may first refer to its color, shape, texture, or size. If necessary, ask what they think it would taste like. Probably someone will say it is sour. Ask this child what he means by sour. (The way it tastes.) Cut the lemon and let those who are willing taste it.

Materials

Lemon, 1, fresh
Knife, 1, to cut fruit

Activity 1

Give each child a quarter of a slice of bland fresh bread (the less tasty the better!) on a paper napkin. Tell the children to break the bread into four pieces and to eat one piece. (See Figure 1.) Ask them whether it tastes like the lemon. (No.) How could we make it taste more like the lemon? (Put some lemon juice on it.) Move around the circle of children and squeeze a little fresh or reconstituted lemon juice on another piece of bread, for any who would like to try it. Ask whether the suggestion was a good one. Does the bread now taste more like lemon?

Go around the circle again and sprinkle a little salt on another piece of bread. Ask the children to taste the bread and tell how it tastes. (Salty.) Again, go around the circle, shaking a little granulated or powdered sugar on the last piece of bread. Ask how the bread tastes now. (Sweet.)

Discuss with the children how the taste of the bread changed as these three different substances were added to it. Ask the children how they would describe the four bites of bread they tasted. Accept any reasonable suggestions that indicate that they have tasted *plain* bread, *sour* bread, *salty* bread, and *sweet* bread. You might discuss different breads found in the market.

Materials

Napkins, 30, paper
Bread, 8 slices, fresh, bland
Lemon juice, reconstituted or fresh
Salt, 1 container (*Module 7*)
Sugar, 1 container, granulated or powdered (*Module 7*)

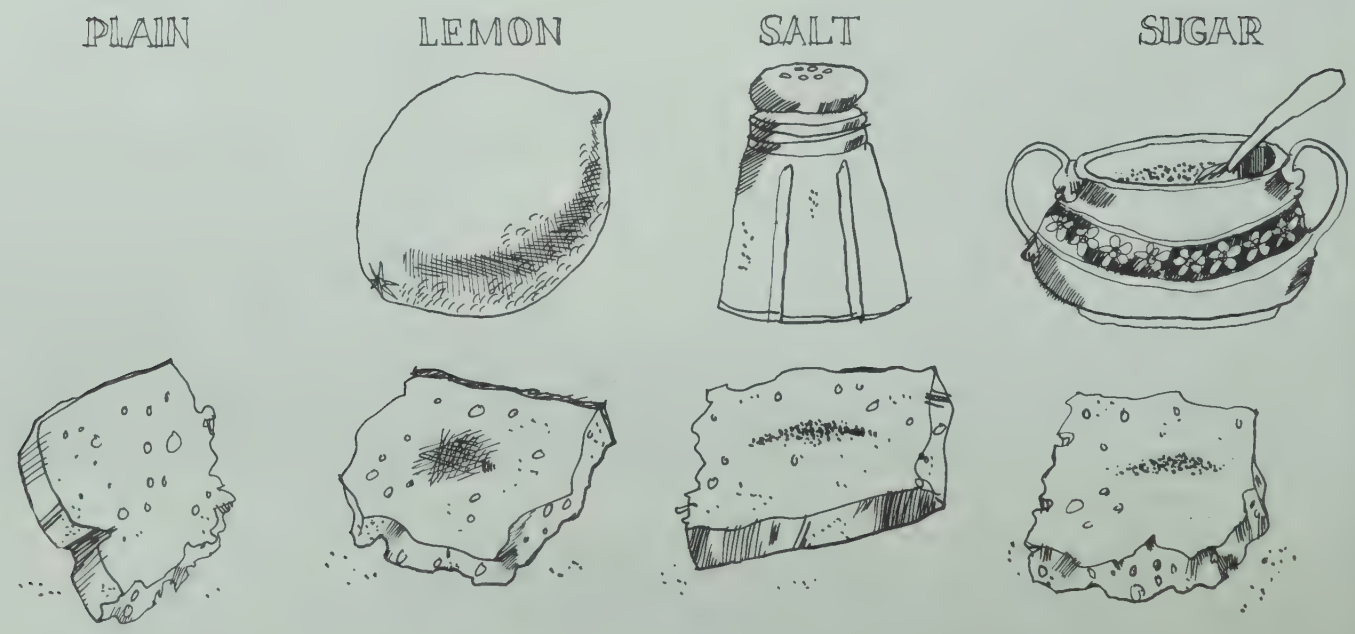

FIGURE 1

Activity 2

Show the children a piece of honeycomb (Figure 2), a lump of sugar, some pieces of sweet chocolate, some cookies, two or three kinds of salted crackers and pretzels, and slices of orange, lemon, and grapefruit. Tell them to group these items in any way they can. Ask whether they are all alike in any way. (They are foods, and all can be eaten.) Ask how they are different. The children will probably mention differences in color, shape, texture, smell, and so on. Accept any reasonable categories. Keep asking for different classifications until someone points out that several of the items are sweet, or salty, or sour. When this difference is mentioned, ask what is meant by "sweet," "sour," and "salty." (The way something tastes.)

Ask questions such as these: Is how something tastes important to us? (Yes. We eat many different kinds of food, and we have to get used to many different kinds of tastes.) Do people all over the world eat the same things? (No. Because people in different parts of the world have different foods around them, they eat from among the things they can get.) But would everyone agree that these foods taste sweet? Point to the group of sweet things as you ask this. (Yes.) And these would be sour? Point to the lemon and grapefruit as you ask this. (Yes, although there may be some argument about whether the grapefruit is sweet or sour.) And everyone would agree that these crackers and pretzels taste salty? (Yes.)

Ask the children if some of them would like to taste some of these foods to see whether they agree that they are sweet, or sour, or salty. Have the volunteers taste the foods using their fingers or plastic spoons. Encourage the children to discuss the tastes to reinforce the identifications.

Tell the children that being able to taste something gives us another way to describe it, but that we don't use this sense to test anything unfamiliar, as we might use our other senses. Ask them if they can think of reasons why this might be the case. Is it safe, for example, to look at something, or to listen to something? Can we smell things safely? (If we do it carefully.) In the discussion, be sure to emphasize the danger of tasting anything unfamiliar.

Materials

Honeycomb or honey, 1 small comb or jar
Sugar, 1 package, cubes (*Module 7*)
Chocolate, 30, squares, sweet
Oranges, 2 or 3, fresh, sliced
Grapefruits, 2, fresh, sliced
Lemons, 2 or 3, fresh, sliced
Cookies, 6
Crackers, 12, salted, two varieties
Pretzels, 6, salted
Spoons, 30, plastic (*Module 7*)
Knife, 1
Paper towels

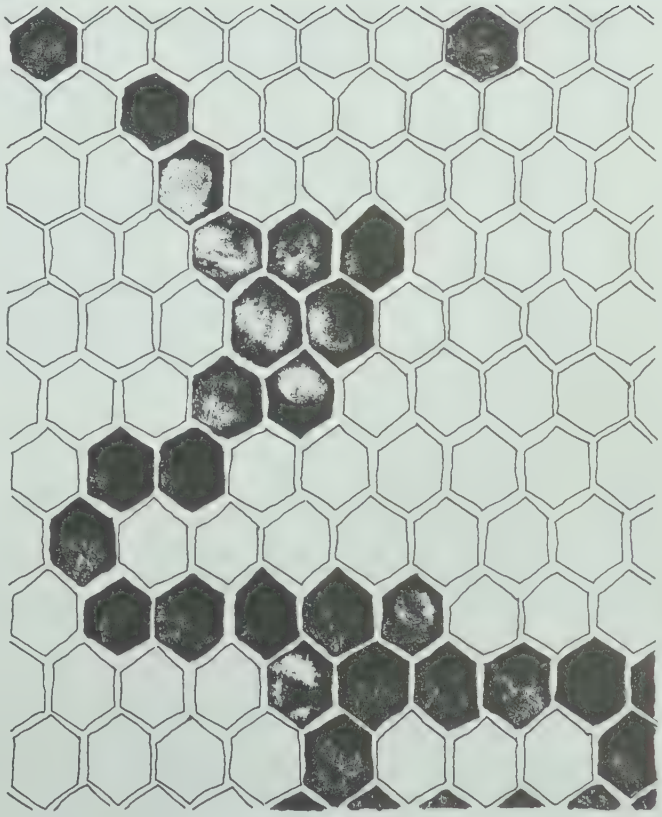

FIGURE 2

Activity 3 (Optional)

(Note: This activity might be done either by the whole class or only by those individual children who wish to go beyond the class activities.)

Suggest to the children that they might collect a number of food items and place them into the three taste groups—that is, sweet, sour, or salty. Their groups could be placed on display around the room. A time might be set for a "tasting" party, the object of which would be to see if the class agreed with the grouping.

Children might also make collages of one or more of the groups, using either real objects, labels of the objects, or pictures of the objects cut from magazines. These collages would then be put on display.

Materials

Foods, an assortment of sweet, sour, and salty
(Note: Be sure the samples are properly identified and that no harmful foods are included.)
Magazines, an assortment
Knife, 1
Spoons, 30, plastic (*Module 7*)
Paper towels

Generalizing Experience

Ask the children if they like lemonade. Have two similar pitchers or bottles, one filled with mixed frozen lemonade which is sweet, and the other filled with a mixture of reconstituted lemon juice and water that is unsweetened. Ask for volunteers to taste the lemonade and describe its taste. Give some of the volunteers the sweetened lemonade and others the unsweetened. One of the children who gets the unsweetened lemonade will probably make a face, and you can ask him what is the matter. (It isn't sweet.) Ask one of the children who tasted the sweet lemonade whether it tasted sweet. (Yes.) Does it also taste like lemon? (Yes.) Is it also sour? (Yes.) Then the sweet lemonade has two tastes: sweet and sour.

Ask the children to try to find other foods during their mealtimes at home which have the basic tastes they have learned, or mixtures of them. Discuss these as the children mention them.

Materials

Pitchers, 2, or bottles
Lemonade, 1 liter, sweet
Lemon juice and water, 1 liter, unsweetened
Cups, 30, paper, small (*Module 7*)

APPRAISAL

Put a container of diluted cider vinegar, a dish of salted nuts, and some sour lemon drops on a table. Let the children taste as many of these as they wish, and then individually identify the tastes to you. They should identify the sour lemon drops as both sweet and sour. If they identify them as one or the other, ask if the lemon drops have another taste too.

Materials

Container, 500-ml (*Module 6*)
Cider Vinegar, 1 bottle
Nuts, 1 package, salted
Sour lemon drops, 1 for each child, candy

COMPETENCY MEASURE

On a table in front of the child, put some bits of sweet chocolate, some salted nuts, a lump of rock salt, and two widemouthed containers, one containing a sugar solution colored with red food coloring and one containing some diluted white vinegar colored with a little blue food coloring. Have paste sticks available.

TASK 1 (Objective 1): Give the child a paste stick. Point to the jar containing the sugar solution and say, Dip your stick into this jar and taste this liquid. When the child has done this, give him a piece of sweet chocolate and a salted nut and say, Taste these and tell me which of them tastes like the liquid you just tasted. The child should say that the chocolate tastes like the liquid.

TASK 2 (Objective 3): Ask, What do we call tastes like the chocolate and the liquid? The child should say they are called sweet.

TASK 3 (Objective 3): Give the child another paste stick. Point to the jar containing the diluted vinegar and say, Dip your stick into this jar and taste this liquid and tell me what we call the taste of it. The child should say it is sour.

TASK 4 (Objective 1): Ask, Is the taste of the second liquid like the chocolate? Wait for his reply. Then ask, Is it like the nut? The child should answer both questions negatively.

TASK 5 (Objective 2): Say, Point to one of the objects on the table that is salty. The child should point to the nuts or the rock salt.

Materials

Chocolate, 1 package of sweet bits
Nuts, 1 small package, salted
Salt, 60 g, rock
Containers, 2, 500-ml, (*Module 6*)
Sugar, 1 package, for the sugar solution (*Module 7*)
Vinegar, 250 ml, diluted white (*Module 6*)
Paste sticks, 3
Food coloring, 1 container, blue (*Module 5*)
Food coloring, 1 container, red (*Module 5*)

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7 Observing/d

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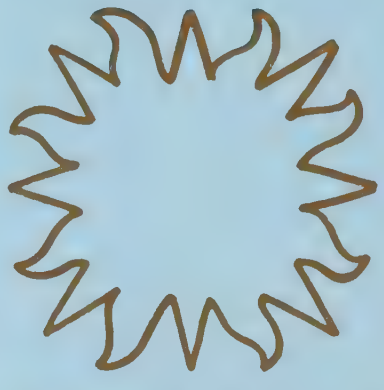

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SCIENCE... A PROCESS APPROACH II

MODULE

8

Measuring/a

Length

OBJECTIVES

At the end of this module the child should be able to

1. *DEMONSTRATE* the sorting of objects into sets in which all objects of one set are of equal length.
2. *ORDER* objects by length, from the shortest to the longest.
3. *DEMONSTRATE* a procedure for comparing the length of two objects by using a third object.

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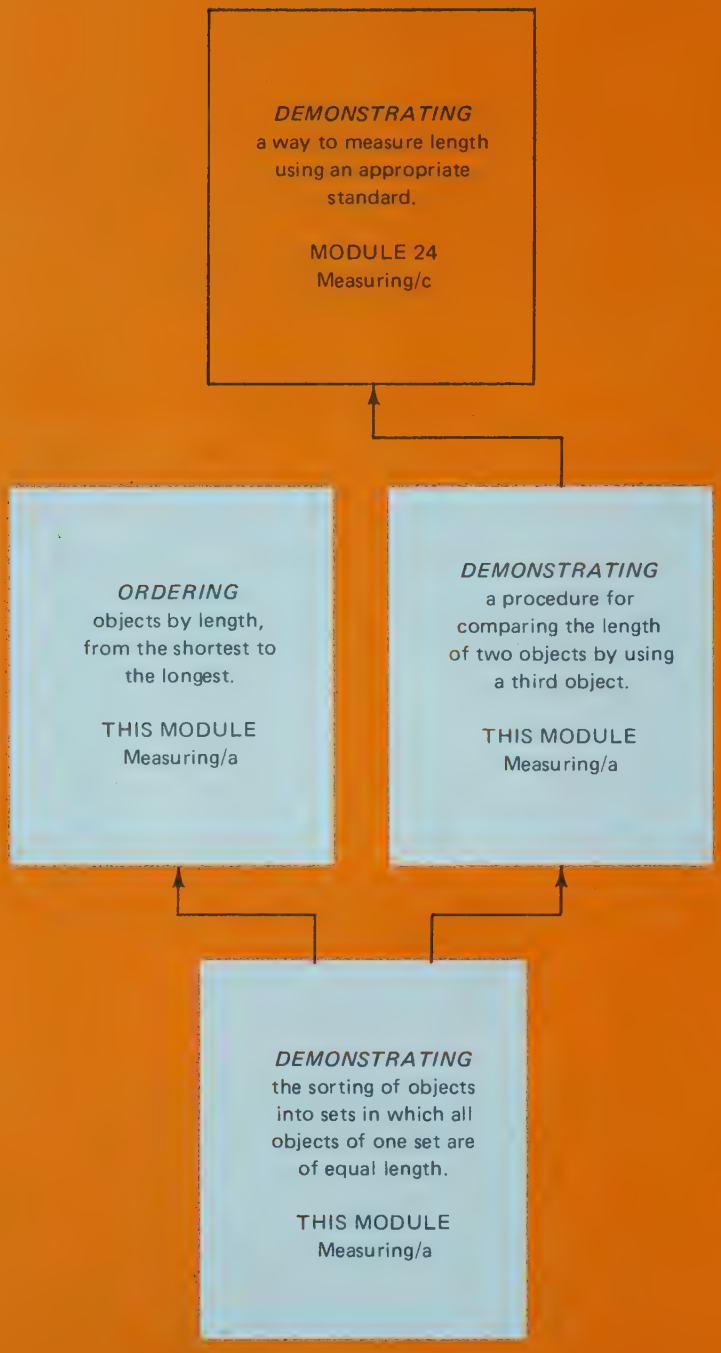
SEQUENCE


DEMONSTRATING
a way to measure length using an appropriate standard.
MODULE 24
Measuring/c
ORDERING
objects by length, from the shortest to the longest.
THIS MODULE
Measuring/a
DEMONSTRATING
a procedure for comparing the length of two objects by using a third object.
THIS MODULE
Measuring/a
DEMONSTRATING
the sorting of objects into sets in which all objects of one set are of equal length.
THIS MODULE
Measuring/a

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II**, is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

Science . . . A Process Approach II

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0–663–29657–9

RATIONALE

This is the first of several modules intended to develop skill in the process called *Measuring.*

In earlier modules the child made observations which he reported in words and phrases. His observations were qualitative. For example, he might have reported that a rectangle has two "short" sides and two "long" sides.

In this module the measuring process is limited to comparing lengths. The child makes comparative observations such as "longer than," or "shorter than," or "the same as." He then learns that he can extend the process of measurement by comparing each of two objects with a standard unit of length, and not directly with each other.

Vocabulary

fits side by side	next to
same length	even
longer than	set
shorter than	

INSTRUCTIONAL PROCEDURE

Introduction

Call on two children of approximately the same height to stand up. It will be best if they are not close to each other. Ask the other children which of the two is taller. Wait for several opinions and then ask how they might be sure who is taller. Someone will probably suggest that the two children should stand side by side or back to back so that their heights can be easily compared. When the question is resolved, call on another pair of children and compare their heights. If you wish, ask which of the two children has longer arms, and again let them compare the lengths as the two children stand back to back and stretch their arms out. In the course of the activity, comment that the children are "comparing lengths."

Activity 1

Divide the children into groups of five or six. For each group, scramble in a single pile four or five rods from each of the eight sets of rods listed under *Materials*. Ask a child in each group to select one rod from the pile. Then ask the other children for suggestions of ways to find all the other rods of the same length as the rod the first child is holding. The response you want here is that the rods can be matched with the first one. Suggestions should come from the children and not from you. Offer suggestions only if no child suggests a satisfactory procedure. Regardless of the procedure used, the children should make one end of each rod even with one end of the rod selected as a standard, and then decide whether or not the rods are the same length. When a procedure has been established, ask the child to find all the rods that match the first one he selected. Tell him to put all the rods that do not match it in another pile, a pile of unsorted discards.

When the first child in each group has all the rods separated into two piles, select another child, one from each group, to repeat the process by choosing a rod from the unsorted pile and again sorting the remainder into two piles—one made up of those that match in length, another of unsorted discards. Continue until all the rods have been sorted into piles containing members of the same length. At some point in the sorting activities, you may either want to ask how this is like other sorting they have done, or refer to the sorting as "classifying."

Each group may then scramble their rods into a pile and the procedure may be made more difficult by having each child select from the unsorted pile one rod which he

believes will match another he is holding. This activity will help develop skill in judging relative lengths by sight without a side-by-side comparison.

Materials

Rods, 240, 30 of each length: 6 cm, 8 cm, 10 cm, 12 cm, 14 cm, 16 cm, 18 cm, and 20 cm (*Module 8*)

Activity 2

Prepare several posters by gluing to cardboard, paired strips of paper exactly as long as the various rods. See Figure 1. Or, outline the rectangular lengths on the cardboard with ink or paint. You will need several posters of increasing degrees of complexity. The least complex should have a few pairs in which the differences in lengths are about five centimeters. On the other hand, the most complex might include several pairs which differ in length by only two centimeters.

Point to a strip on a poster and ask a child to locate another strip which is the same length. In the introductory lesson, the child was able to match two objects directly. Here the child must use a different technique to solve the measurement problem because the objects being matched cannot be moved. The children may see the need of a movable "tool" to make the necessary comparisons in this activity. Accept the use of any suitable tool such as a finger, a hand, a pencil, or a rod. (See Figure 1.) After the child has determined which strips are of equal length, ask him to identify the pairs by coloring them the same color.

Ask other children to continue the matching and identifying until all of the posters have been completed. A set of mimeographed sheets, of graduated difficulty, to match the posters could be used to supplement this activity.

To reinforce the use of a movable tool, you may choose to do the following. Label empty containers with the colors used to identify the paired strips on the posters. Scramble the rods into several piles, and invite the children to sort the rods by matching them with the strips of paper and then putting them in the container of the same identifying color. As they go about their task, the children may see that it is not necessary to match each rod with the strips of paper, but that they may use one of the rods previously matched with a paper strip as a movable tool to find the others of equal length. If this does not become obvious after a reasonable amount of time, you might ask if anyone can think of a quicker way of doing the sorting.

Materials

Cardboard, for posters, several pieces
Paper strips, 80, 10 of each length: 6 cm, 8 cm, 10 cm, 12 cm, 14 cm, 16 cm, 18 cm, and 20 cm (*Module 8*)
Crayons, 8 colors
Rods, 240, 30 of each length: 6 cm, 8 cm, 10 cm, 12 cm, 14 cm, 16 cm, 18 cm, and 20 cm (*Module 8*)
Containers, 8, such as boxes (*Module 8*)
Mimeograph sheets, similar to posters (optional)

FIGURE 1

Activity 3

Arrange the rods into sets that contain one rod of each length. Separate the class into small groups and give each group a set of rods.

Ask each group to select from the pile the one rod they believe to be the shortest and to place it on the table. Then have them select the next longer rod by sight, compare it with the first for length, and place the longer rod next to the shorter rod. Have them continue selecting, comparing, and placing the remaining rods until all are ordered into a sequence from the shortest to longest. Accept any arrangement that complies with these directions. (See Figure 2.)

Select small groups of children to sort, by length, objects such as pencils, building blocks, books, and toys, and then order them from the shortest to the longest. The children may have difficulty with irregular objects such as toys. Let the children decide how to measure the lengths of such objects.

Materials

Objects, an assortment, such as pencils, blocks, or other objects found in the classroom

Rods, 240, 30 of each length: 6 cm, 8 cm, 10 cm, 12 cm, 14 cm, 16 cm, 18 cm, and 20 cm (*Module 8*)

FIGURE 2

Generalizing Experience

Cut holes in the two narrow sides of large paper shopping bags, about a third of the distance down from the top. The holes should be just large enough for a child's arm to reach through. Two children should be able to reach into the bag at the same time. (See Figure 3.)

Divide the children into five or six small groups and give each group a bag and an assortment of rods. Have two children in each group put the rods in the bag, and then fold and clip the top together. Explain that pairs of children in each group will take turns being "It." The first pair will each put an arm into the bag and try to follow the instructions others give. For example, one of the group might say, "Find two rods that are the same length," or "John must find a rod shorter than one Ann chooses." The children with their arms in the bag will have to match the rods without being able to see them, and they will need to cooperate if one child is to hold the ends of two rods together while the other feels the opposite ends. When they think they have found what was asked for, they should draw the rods out of the bag carefully so that the other children can verify the selection. When the group is satisfied, the rods should be returned to the bag and then another pair of children should take its turn.

If you wish, vary the game with other objects which can be compared in length.

Materials

Bags, 6, large, paper (*Module 8*)
Scissors, 1
Rods, 240, 30 of each length: 6 cm, 8 cm, 10 cm, 12 cm, 14 cm, 16 cm, 18 cm, and 20 cm (*Module 8*)
Paper clips, 1 box, large

FIGURE 3

APPRAISAL

Give each child 15 strips of paper cut from a random selection of colored paper. The set of 15 might include four strips of different colors, each 18 centimeters long; three strips of different colors, each 15 centimeters long; four strips of different colors, each 13 centimeters long; and so on.

Ask the children to place all the strips of each length into a pile. Watch to see if they determine three strips to be of the same length by making two comparisons, rather than three.

Have each child order the various strips by length and paste the arrangements on a sheet of paper. Or, you may prefer to have the children paste on the paper only one strip of each length.

Materials

Strips, 450, paper, five different lengths and many different colors
Paste, 1 jar
Paper, 1 sheet for each child

COMPETENCY MEASURE

Prepare four sets of nails. Each set should consist of three different kinds of nails that are of equal length. The nails of different sets should differ in length. Scramble all of the nails together so that you have a completely unsorted pile of nails.

TASK 1 (Objective 1): Say, Sort the nails into sets in which each nail is of the same length. The child will succeed in this task if he sorts all of the nails into sets where the nails are of equal length.

TASK 2 (Objective 2): Place four nails, each a different length, in front of the child. Say, Order this set of nails from the shortest to the longest. The child should so order each set.

TASK 3 (Objective 3): Remove all the nails from the test area. Choose three nails which are of the same length, but of different kinds. Give the child one of the nails and hold the others, one in each hand. Give the child one of the two nails that you are holding. Ask, Is this longer than, shorter than, or the same length as the nail you are holding? He should compare the lengths and respond that they are the same length.

TASK 4 (Objective 3): Have the child return to you the second nail you gave him. Give him the nail which is in your other hand, and ask, Is this nail longer than, shorter than, or the same length as the nail you have? The child again should compare the two nails and say that they are the same length.

TASK 5 (Objective 3): Have the child return the third nail you have given him. Ask, What can you say about the lengths of the two nails I am holding? The child should say that the nails are the same length.

Materials

Nails, 12, 3 different kinds, 4 lengths of each kind (*Module 8*)

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8 Measuring/a

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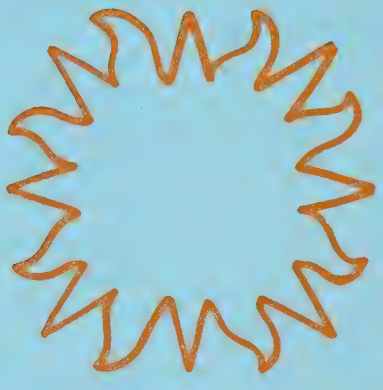

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MODULE

9

Using Numbers/a

Sets and Their Members

OBJECTIVES

At the end of this module the child should be able to

1. *IDENTIFY* various sets of objects when given the names or characteristics of their members, *IDENTIFY* a member of a set, and *IDENTIFY* a set having only one member.
2. *IDENTIFY* as equivalent two sets which contain the same number of objects, by pairing each object from the first set with a corresponding object from the other set.
3. *IDENTIFY,* given two sets which are not equivalent, the set that has
   (a) fewer members, or a smaller number of members, or
   (b) more members, or a greater number of members.
4. *IDENTIFY* the set among three, no two of which are equivaient, that has
   (a) the fewest members, or the least number of members, or
   (b) the most members, or the greatest number of members.

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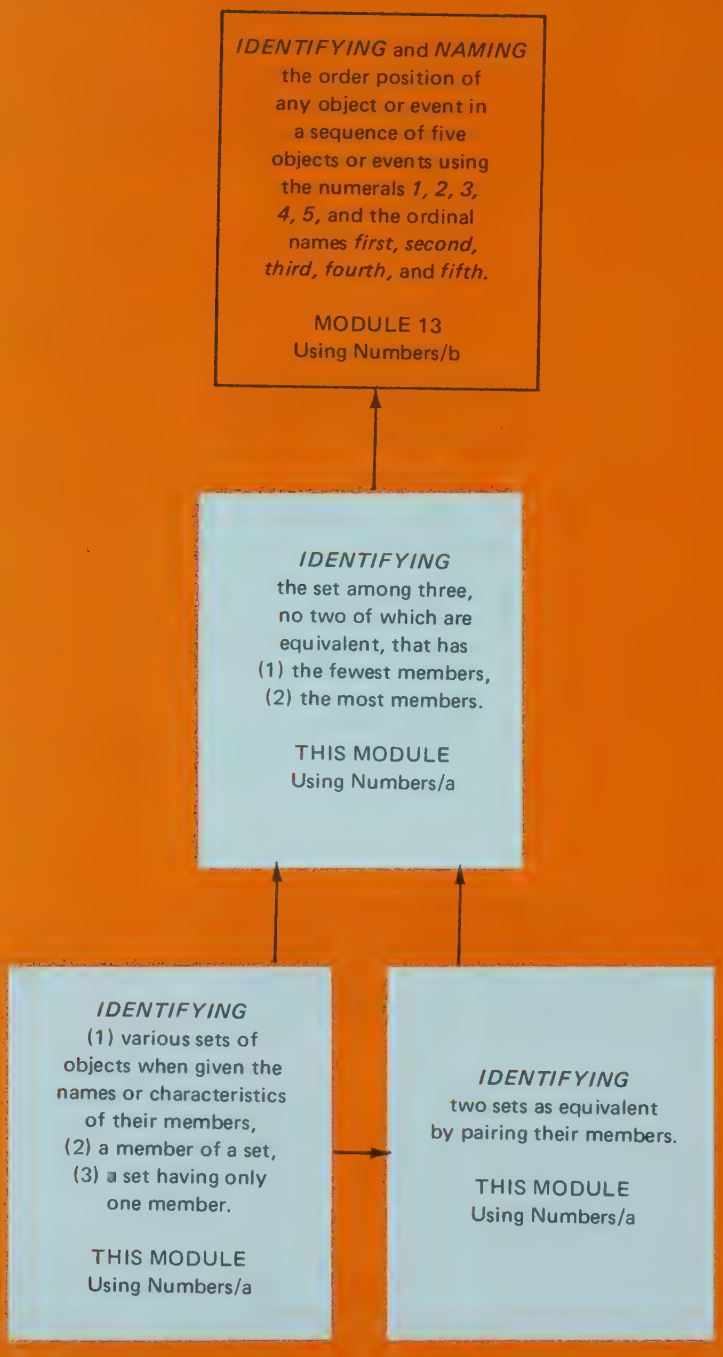
IDENTIFYING and *NAMING* the order position of any object or event in a sequence of five objects or events using the numerals *1, 2, 3, 4, 5,* and the ordinal names *first, second, third, fourth,* and *fifth.*
MODULE 13
Using Numbers/b
IDENTIFYING the set among three, no two of which are equivalent, that has (1) the fewest members, (2) the most members.
THIS MODULE
Using Numbers/a
IDENTIFYING (1) various sets of objects when given the names or characteristics of their members, (2) a member of a set, (3) a set having only one member.
THIS MODULE
Using Numbers/a
IDENTIFYING two sets as equivalent by pairing their members.
THIS MODULE
Using Numbers/a

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

Recognizing and using numbers and number relationships is one of the processes of science, and in this process-centered approach to science education, the study of numbers is made an integral part of science. Ideally, all numbers activities of the class should be closely integrated with the science activities.

In the *Introduction* to this module, the word *set* is used synonymously with collection or group, and the term *member of a set* is also introduced. Children should be familiar with these terms as they were used in *Leaves, Nuts, and Seashells.* Here the children will learn to use these terms in a simple and natural way as a substitute for other expressions such as *bunch, herd, crowd, group,* or *collection,* as well as *part of a bunch, herd, crowd, group,* and so on. The terms *set* and *member of a set* will give them an easy and precise way to communicate and will also help them to develop the ideas of numbers and counting.

When children work with several sets of objects, they should be able to tell whether two (or more) sets have the same number of objects. They also should be able to determine whether a given set has more or fewer members than a second set.

One approach to the notion of the number of members of a set is to arrange a pairing, or matching, process in which one member of a given set is paired with one member of a second set, introducing the fundamental idea of one-to-one correspondence between the members of the sets. This in turn leads to the definition that sets are equivalent when they have the same number of members, as shown by establishing a one-to-one correspondence between the members of the sets.

Through these activities, those children who are able to count by rote should recognize just what it means for one set to have a certain number of members and another to have a different number of members. For example, one set might have six members and another, seven.

Primitive notions of order are introduced, but the examples are mostly limited to comparisons of two sets. Many classes will be ready for a more refined notion of order, however. If you feel that your children are mature enough, you can suggest that they compare the number of members in more than three sets, no two of which are equivalent.

Vocabulary

set	fewer
pair	most
equivalent sets	fewest
more	one-to-one correspondence
number	one-to-one pairing
member	greater
same	less

INSTRUCTIONAL PROCEDURE

Introduction

Show the children a set of disks or some other set of objects and ask what it is. Repeat with a set, or a picture of a set, of dishes, golf clubs, or some other set of objects. Try to get the children to say the word *set* first. Then emphasize it.

On a table in the front of the room have a set of plane shapes for the children to examine. Ask them to identify the shapes. Arrange the shapes in various ways and eventually group several squares. Ask the children if this is a set of square shapes. Choose the circles and ask them what they might call this collection. Have volunteers form other sets, and then name them using the term *set.* (See Figure 1.) Help the children identify the ellipse as a set with only one member.

Follow a similar procedure with collections of other objects, such as metal objects, rocks, or books. Include some sets with one member—for example, the set of clocks or the set of teachers in the room.

Materials

Disks, several (*Module 10*), or some other set of objects
Picture of dishes, golf clubs, or some such set of objects, 1 (optional)
Cardboard shapes, 13-17, 3 or 4 of each shape: circle, square, rectangle, and triangle, and 1 of an ellipse *(Module 2)*
Objects, a collection

FIGURE 1

Activity 1

The child begins here to develop the technique of pairing by which he can determine whether or not two sets of objects have the same number of members—that is, whether or not they are equivalent. In mathematics, this process is described as establishing a one-to-one correspondence between sets. The aim here is to help the child abstract the concept of number for any particular set before he is introduced to counting and the names for numbers. Of course, many children already know the names of numbers by rote. Accept any statements they may make about the number of members in a set, but do not emphasize this aspect now.

As the children prepare to take a walk, ask the set of all boys to stand on one side of the room and the set of all girls to stand on the other side. Indicate "one boy" and "one girl," and have them stand side by side. Mention that they are "paired," or that they form a "pair." Ask the girl with whom she is paired, and ask the boy with whom he is paired.

Go through the whole class, pairing a boy with a girl and asking each boy in turn to say "one boy" and each girl to say "one girl" as they are paired. Repeat that they are pairing "one boy" and "one girl." If there are boys or girls left over when the pairing has been completed, ask whether there are more girls or more boys. If there are leftover boys (or girls), ask one of them with whom he (or she) can make a pair. He (or she) should say, "Nobody." Then let the unpaired children or child form a single line at the end.

Before starting on the walk, ask the children if they can think of sets of objects which can be paired without any leftover. Possible examples are the set of cups and the set of saucers, or the set of children and the set of their milk cartons. Whenever possible, suggest pairing "one cup" and "one saucer," or "one child" and "one milk carton."

Activity 2

1. Arrange to have the same number of chairs in the room as there are children. When the children are sitting in a circle on the floor, ask them how they can tell that the two sets—the children and the chairs—are alike. (By pairing the members of the two sets, "one child" and "one chair.") Have one child sit in one chair. Ask what you call the child and the chair. (A pair—"one child" and "one chair.") Then, one by one, tell each child to go sit in a chair. When all are sitting, each child is paired with a chair and each chair is paired with a child. No child is left over, and no chair is left over. The pairing comes out even. Tell them that this process of pairing establishes a "one-to-one pairing" or a "one-to-one correspondence" between the sets. When this can be done, the sets are called equivalent sets.

Ask such questions as these: Are the set of children and the set of their noses equivalent sets? The set of children and the set of their tongues? The set of right hands and the set of left hands? The set of eyes and the set of eyebrows?

Tell the children to change their seats. Again, no children or chairs are left unpaired. Ask the children what they can say about the two sets. They should say that there is one-to-one pairing of children and chairs so the sets are equivalent, although the pairing is different from what it was at first. Mention that they are finding ways to show that two sets may be alike even though their members (children and chairs) are not alike. Such sets are said to have the "same number of members," or "the number of children is the same as the number of chairs." Figure 2 illustrates this.

2. Place the set of party hats on a table. The number of hats should be less than half the number of children in the room. Select a number of children numbering one more than there are hats. Ask this group if the set of children and of hats is equivalent. Have each child take one hat. Again, ask if the two sets are equivalent. (No.) Ask why the sets are not equivalent. (Somebody has no hat.) Have the children put the hats back on the table. Starting with the boy or girl who had no hat, tell each child to take a different hat. Again, ask if the sets are equivalent. (No.) Have the children return the hats to the table and go to their seats.

Now call up a new set of children consisting of the same number as the set of party hats, and repeat the pairing procedure. Ask the class what they could say about these sets. (They are in one-to-one correspondence; they are equivalent.) Emphasize that no member of either set is left unpaired. Have the children speak of the sets as sets with the same number of members, or sets of the same number. Ask them if the number of children is the same as the number of party hats. (Yes.) You may also wish to say that the number of children is "equal" to the number of party hats. Note that we say "the sets are equivalent," but the *number* of the set of children is *equal* to the *number* of the set of party hats.

You might continue this activity by playing a game of musical chairs.

3. Show the class two sets of five objects, such as a set of five cubes and a set of five chairs, or a set of five spheres and a set of five toy cars. Choose a third set consisting of five children. Ask such questions as these: Is the set of children equivalent to the set of chairs? Is the set of cubes equivalent to the set of chairs? What does this tell us about the set of cubes and the set of children? (These sets are also equivalent, or the number of children is the same as—that is, equal to—the number of cubes.) Then go through the actual demonstration by pairing (establishing a one-to-one correspondence).

Now ask the question, What can we say about all three sets? (The three sets are equivalent. The three sets

have the same number: the number of cubes, the number of chairs, and the number of children are all the same or are all equal.) Remind the children that these are other ways of saying that each set has the same number of members.

You can introduce variety into this activity by repeating it with different objects and by using three (or four) members in each set. Emphasize the idea that when two sets are each equivalent to a third set, the two sets are themselves equivalent. Indeed, all three sets are equivalent and have the same number of members.

After the demonstration, give the children the opportunity to carry out this activity in groups of five using sets of five cubes, five spheres, and five chairs (or other objects). If it is convenient, let the children themselves form one of the sets.

Materials

Chairs, 1 for each child
Party hats, 10 (*Module 9*)
Objects, 10-15, two or three sets of five objects, such as a set of five cubes or spheres (*Module 3*), or five toy cars (*Module 9*), or five chairs

FIGURE 2

Activity 3

1. Begin with a set of three cubes and four toy cars. (You could also use other objects, such as balls, toy animals, or chairs.) Ask the children whether the set of cubes is equivalent to the set of cars. Ask them how can they tell. (There is one car left after pairing.) Then ask them if there are more cars than cubes or fewer cubes than cars. (There are more cars because one car is left after pairing.)

When the children accept the idea of "fewer than" and "more than," tell them that the number of cars is "greater than" the number of cubes. Also, the number of cubes is "less than" the number of cars. (See Figure 3.)

Extend the demonstration to include a third set of two balls. As before, let the children compare the number of balls with the number of cubes and with the number of cars.

(Note that the expressions *more than* and *fewer than* apply in dealing with the members of the set. For example, there are *more* cars *than* cubes. But with numbers, the expressions *greater than* and *less than* are appropriate. Thus, the number of cars is *greater than* the number of cubes.)

2. Show the children three sets of cubes, consisting of two, three, and four cubes. Pile the cubes of each set in a different column to convey the idea of separate sets that contain different numbers of members. Ask the children how they would arrange them. The various heights of the piles will probably suggest steps and an arrangement by increasing height. Discuss the fact that the set of three cubes has more members than the set of two cubes, and so on. Ask which set has the *most* cubes and which has the *fewest*. Point out that the *most* corresponds to the set with the *greatest number*, and that the *fewest* corresponds to the set with the *least number*. Emphasize that the greatest number has been arranged on one end, the least number on the other, and the remaining number in the middle.

Now repeat the activity with sets of two balls, three cubes, and four cars. (Be careful that you treat these sets as entities, and that you do not allow individual objects from different sets to become mixed.) Ask whether there are more cubes than balls, more cars than cubes, and so on, until the children can make these comparisons easily. Rephrase these comparisons by asking such questions as: Is the number of balls less than the number of cars? Is the number of cubes greater than the number of balls? Then ask which number is greatest and which is least.

The children probably will readily accept the description that the number of cars is greatest and the number of balls is least, and they will be willing to associate *fewest* with *least number* and *most* with *greatest number*. Also, mention that the number of cubes is between the number of balls and the number of cars. Relate this to the comparison that the number of cubes is greater than the number of balls, but less than the number of cars.

Materials

Cubes, 9 (*Module 10*)
Cars, 4, toy (*Module 9*)
Balls, 2 (*Module 9*)

FIGURE 3

APPRAISAL

1. Give each group of four to six children a box with five crayons, five small cubes, and four disks, or other objects in the same quantity. Tell them to take out the cubes, the crayons next, and finally the disks. Then ask them to decide which of these sets of objects are equivalent or have the same number. If you ask several children individually what they have decided, you can use their answers as an appraisal of how well they have met the objectives. Ask those who do this successfully to use the objects that you gave to the group to make a set that has the same number of members as the set that you placed on a table at the front of the room.

2. As opportunity permits, give a child a collection of disks and cubes. Each set should contain six or more members. Determine whether the child can answer questions of this sort: Are there more (or fewer) disks than there are cubes? Then ask the child to show you how he could tell this.

For two sets differing by one, ask questions such as: Which set has more members? Can you show me the pairs? There is one left over. What does this tell you about these sets?

If the children simply "count" the two sets, ask if they know any other way to tell which set has more members, and encourage them to check their answers by making pairs consisting of one from each set. Ask them the question, Are any left over?

(Note: If part 2 of the *Appraisal* is too time-consuming as individual tests, work with groups of five or six children at a time, asking individuals to report the answers.)

Materials

Boxes, 4-6, shoe or any other type
Crayons, 20-30
Cubes, 20-30 (*Module 10*)
Disks, 30 (*Module 10*)
Objects, 4, displayed at the front of the room

COMPETENCY MEASURE

(Note: If a child responds to any of these questions by counting, ask, Is there any other way you can find out? Do not record responses as acceptable unless the child used the idea of one-to-one correspondence.)

Give the child a collection of five crayons, six paper clips, and one button. (Other items may, of course, be substituted.)

TASK 1 (Objective 1): Say, Show me the set of crayons, and then give me a member of the set. The child will complete this task successfully if he collects the crayons together in a set and then gives you one crayon.

TASK 2 (Objective 1): Say, Show me the set of buttons. The child should show you the one button.

Gather all the objects in one place and add one crayon and four buttons to the collection.

TASK 3 (Objective 2): Say to the child, Without counting, show me how we can tell whether there are the same number of crayons and paper clips. The child will respond to this question correctly if he pairs these two collections.

TASK 4 (Objective 3): Ask, Are there more buttons or more crayons? Show me how to find out. The child should pair these two collections and state that there are more crayons.

Gather all the objects in one place again and add two more crayons without the child's seeing what you add.

TASK 5 (Objective 4): Ask, Which collection of objects has the greatest number of members? Show me how to find out. The child should use a pairing procedure to identify the set of crayons as having the greatest number of members.

Materials

Crayons, 8
Paper clips, 6
Buttons, 5

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9 Using Numbers/a

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MODULE
10

Using Space/Time Relationships/c

Spacing Arrangements

OBJECTIVES

At the end of this module the child should be able to

1. *CONSTRUCT* these shapes: triangle, circle, square, rectangle, and ellipse.
2. *CONSTRUCT* an arrangement of objects in the forms of familiar two-dimensional shapes.
3. *IDENTIFY* and *NAME* the two-dimensional shape formed by a given arrangement of objects.

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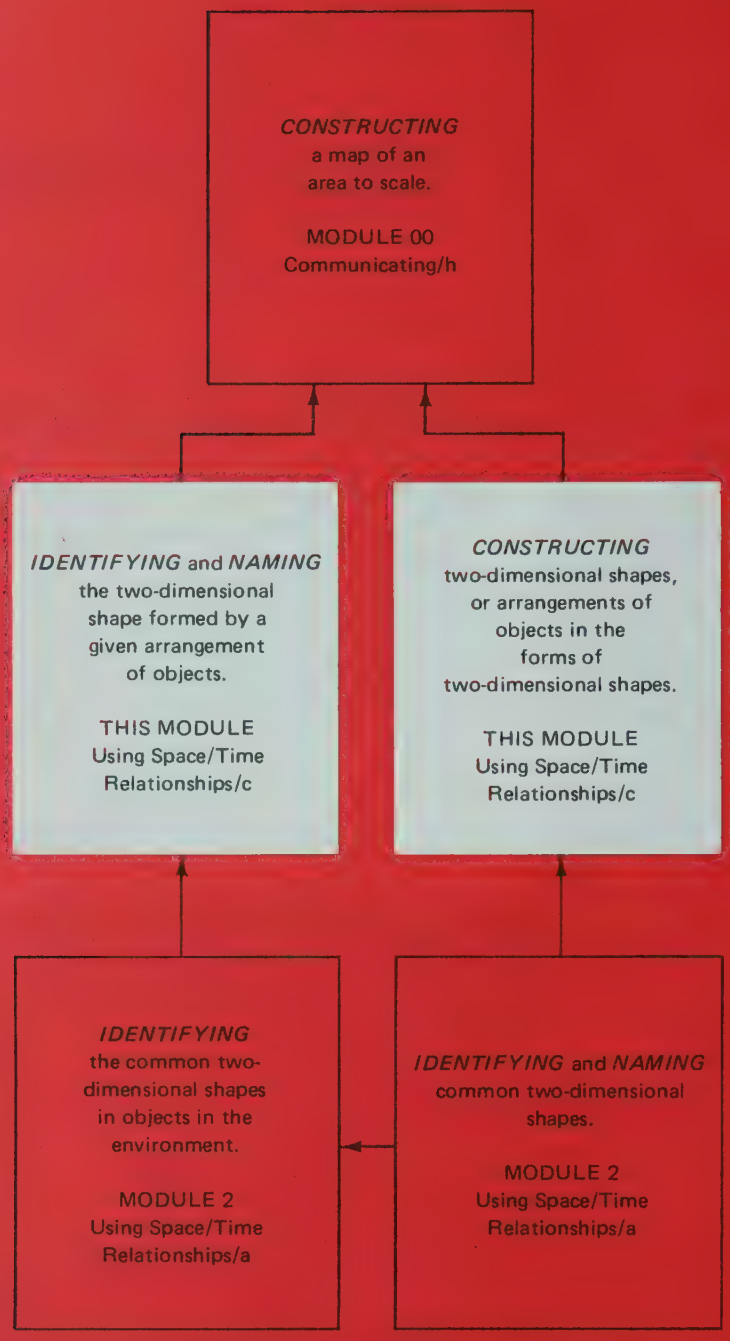
SEQUENCE



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RATIONALE

In this module the children construct two-dimensional shapes using rods, string, pieces of paper, or other appropriate material. They also draw the shapes with pencil on paper or with chalk on the chalkboard. At this stage the children will not be able to draw shapes that are accurate, but they should be able to produce drawings that almost anyone could name correctly. In this module as in other modules in the early parts of *Science . . . A Process Approach* no distinction is made between line and line segment. This should create no problem in later work.

Diagrams are introduced to represent arrangements of objects and persons to form familiar two-dimensional shapes. In *Using and Recognizing Shapes, Using Space/Time Relationships a, Module 2,* the children learned how to recognize these shapes. Now they learn to interpret diagrams representing these shapes, and to identify and name the shapes.

The skills introduced in this module are important. Recognizing that arrangements of objects or persons can be represented by diagrams, and, conversely, that objects and persons can be arranged according to a diagram, are necessary prerequisites to graphing and mapping.

Activity 5 is a game for pairs of children. As many children as are interested should be encouraged to play. After two or four children have played they should be able to teach others so that the activity can become peer-instructional.

Vocabulary

arrange
arrangement
diagram

INSTRUCTIONAL PROCEDURE

Introduction

Briefly play a game in which you hold up a large, cardboard, two-dimensional shape and ask a child to name it. If he names it correctly, let him hold the next shape for another child to identify. When all the shapes have been named and the interest is still high, show the children a triangle or rectangle they have named and turn it 90°. After they have named the shape correctly again, turn it 45° more. Do the same with a square. (See Figure 1.)

You might have the children draw a rectangle on a piece of paper when the rectangle is held up. When the rectangle is turned through 90°, have the children turn their rectangles through 90° Follow these suggestions with other shapes if most of the children can make reasonable sketches.

Materials

Cardboard shapes, 5, a square, a rectangle, a triangle, a circle, and an ellipse (*Module 2*)
Drawing paper, 1 sheet for each child

FIGURE 1

Activity 1

Distribute six rods to each child: four rods of one length and two rods of another length. (For example: You might give each of seven children four rods 6 cm long and two rods 10 cm long. For another group of seven, each child would receive four rods 8 cm long and two rods 12 cm long.)

Draw a horizontal line segment on the chalkboard; or, with any suitable material, represent a line on the flannel board. The children can put a rod on their tables corresponding to the drawn line. Have one child draw a second line segment on the chalkboard at the end of the first so that it will be possible to make a triangle. Let another child draw the third line segment. Ask the children how many sides a triangle has.

The children at their seats can make their triangles at the same time the chalkboard triangle is being drawn or the flannel board triangle is being constructed.

Do the same for the other shapes. Children should use either plant ties or pipe cleaners to make the circle and the ellipse.

Ask such questions as these: Why can't two lines be made into a rectangle? Must all the lines making a square be the same length? What is the least number of lines we can use to make a triangle, a square, or a rectangle?

For children whose coordination is not well developed, you might prepare copies of dotted-line drawings of the shapes illustrated in Figure 2. The children should trace around the shapes with their fingers and name the shapes as they do this. They can also fill in the lines with their crayons.

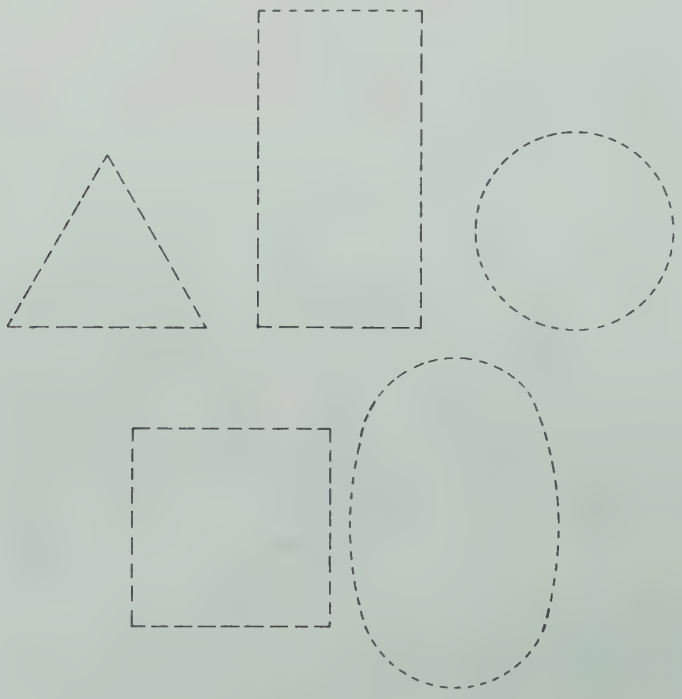

FIGURE 2

After the lesson has progressed to the point where you can introduce more difficulty, present a partial sketch of a triangle (see Figure 3a) and ask a child to complete it. The child may possibly complete the sketch as shown in Figure 3c instead of as in Figure 3b, and then misname the resulting sketch a "rectangle."

If so, you should make paper models of the rectangle and the trapezoid the child drew and ask him and the other children how these shapes differ. Place the trapezoid on the rectangle and ask how the shapes are alike and how they are different. (Note the differences in two of the corners.) You may use the term *trapezoid*, but do not expect the children to add this word to their vocabularies at this time. Some groups might benefit from a discussion of the parallel sides of the rectangle.

Materials

Rods, 180, of different lengths (*Module 8*)
Plant ties or pipe cleaners, 30, (*Module 10*)

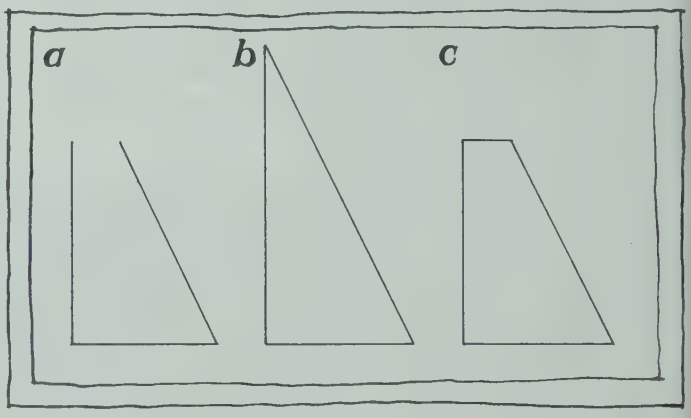

FIGURE 3

Activity 2

Place a length of cord in a straight line on the floor, or in some other way represent a straight line. Ask a child to stand at one end of the line and a second child to stand at the opposite end. Then draw a line on the chalkboard and two stick figures representing the positions of the children, as in Figure 4. Ask the other children to tell you what you have pictured on the board. If they do not see the relationship of the two children and the cord, you may need to ask them if they can see anything in the room that is like the picture. Have them identify both the two stick figures and the line. Once they do this, draw a third stick figure—this time, in the middle of the line on the board.

Now ask a volunteer to take the position on the cord which you have represented by the third stick figure.

Materials

Cord, 1 ball (*Module 10*)

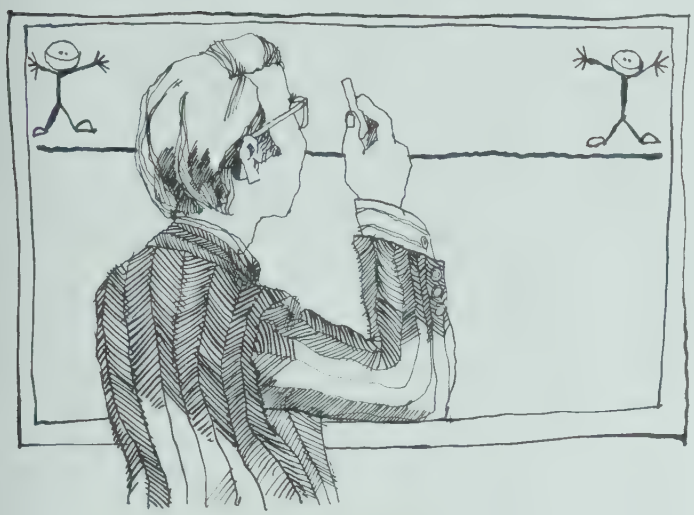

FIGURE 4

Activity 3

Give each child paper and a crayon. On the floor make a triangle out of cord, using masking tape as needed to keep the sides straight. Now draw a similar triangle on the board. Ask the children to make a shape on their papers like the shape formed by the cord. Now put an X in one corner of the triangle on the board, as Figure 5 shows. Ask a child take that position in the cord triangle on the floor. When the child has taken the proper place, make an X where he is standing, so the diagram on the floor will be like the one on the chalkboard. Then ask the children to draw an X on their drawings to show where the child is standing.

Repeat these activities with other shapes, such as rectangles or circles. Ask children to take positions as you designate them by marks on the board; for example, you might mark the center of the circle, or opposite places on the diameter of the circle, or the center or special corners of the rectangle.

Materials

Crayons, 1 for each child
Drawing paper, 1 sheet for each child
Cord, 1 ball (*Module 10*)
Masking tape, 1 roll

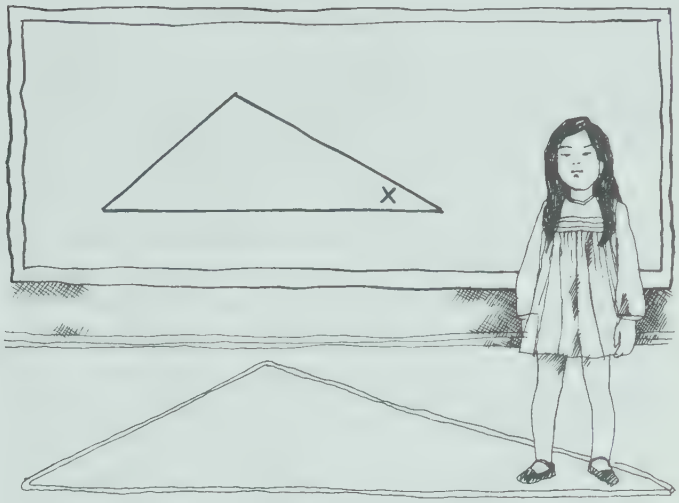

FIGURE 5

Activity 4

Make a square on the floor with cord, soft chalk, or masking tape and draw a similar square on the chalkboard. Label the corners of the chalkboard square *1, 2, 3,* and *4.* Label one corner of the square on the floor so the children will know where to start. Then select four children and assign each child one of the four numerals. Ask each one to look at the drawing on the board, and then to take a position on the floor drawing which corresponds to his numeral.

Give each child about eight objects such as blocks, plastic counting disks, or small pieces of paper. Draw a triangle on the board and have the children arrange the objects in the shape of a triangle. Repeat this activity for a square, a circle, and a rectangle.

Materials

Cord, 1 ball (*Module 10*), chalk, or masking tape
Objects, 8 for each child, such as small pieces of paper, blocks, plastic counting disks

Activity 5

Shape, a peer-instructional game, is designed to provide practice in the arrangement of objects to represent the shapes of triangles, squares, and rectangles.

Child 1 and Child 2 are each given a game card, ten 1-centimeter yellow cubes, and 20 red disks. The children might sit back to back on the floor so that their game cards are concealed from each other. Child 1 arranges some cubes to make a shape on his card as shown in Figure 6. The cubes must form a continuous outline. Child 2 then tries to identify the shape by guessing the positions of the cubes. He guesses positions by calling out the animal at the top of the position, and then the number to the left of the position. For example, the child might say, "Dog, 2." If he guesses the position of one of Child 1's cubes, he marks the position of his guess on his own card with a cube. If he guesses and does not find one of Child 1's cubes, he marks the position of his guess on his own card with a red disk. To win, Child 2 has to guess Child 1's shape before he has found the position of all of Child 1's cubes, and he has to make Child 1's shape exactly on his own card. If Child 2 guesses a triangle, for example, but his triangle is not the same as Child 1's triangle, he has guessed incorrectly. If Child 2 locates all of the yellow cubes comprising Child 1's shape but does not guess the shape, or if he guesses the shape incorrectly, Child 1 wins.

Material

Shape games, 8, each consisting of eight game cards, ten yellow cubes, and 20 red discs (*Module 10*)

Generalizing Experience

Draw a large plan for the room on the chalkboard, showing the location of several objects including several pupils' chairs. First, point to a particular chair on the diagram and tell the child sitting on it to rise or hold up his hand. Then point to another chair on the diagram and tell the child sitting on this one to go to a position in the room which you point to next on the diagram. Point to two chairs on the diagram and ask the two children on those chairs to exchange seats. You can involve all of the children as you assign different groups of children to the chairs in the diagram. If you think the drawing would not be too complicated for your children to interpret, you might include a chair for each child.

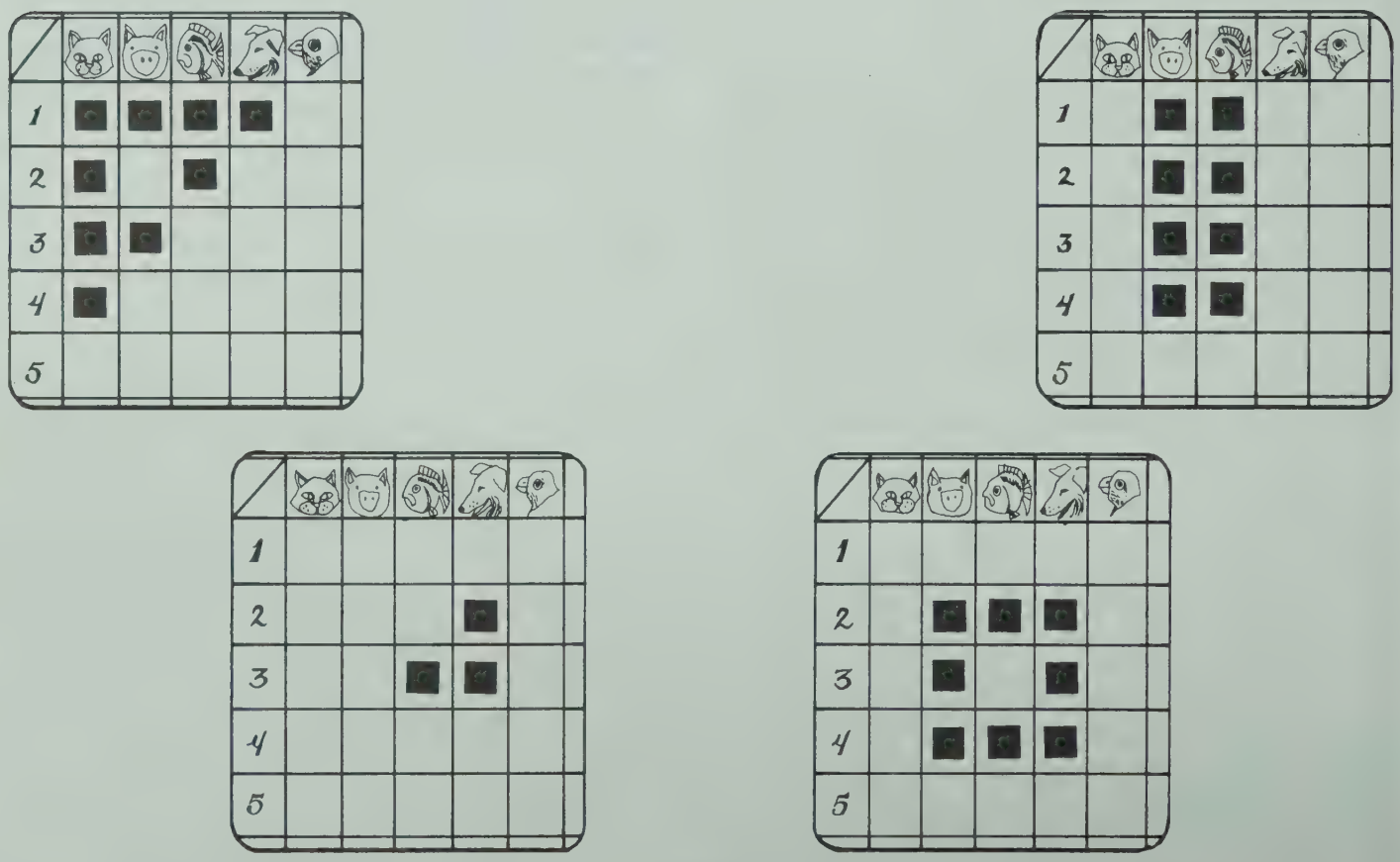

FIGURE 6

APPRAISAL

Select one child to draw various shapes on the board. Divide the rest of the children into several groups, with one child in each group designated as the leader of that group. As a child draws a shape on the board and places two or three X's on the shape to represent the position of children, tell the leader to arrange children from his group according to the shape and the corresponding positions. Change the leaders frequently. You might conduct this activity as a contest.

Arrange several objects (blocks, apples, crayons, or others) in patterns which have the shapes of triangles, rectangles, and circles. Ask the children to name the patterns, using one of the shape names. Let the children see several patterns (shapes) at one time. Also ask the children to draw the patterns.

Materials

Objects, several, such as blocks, apples, or crayons
Drawing paper, 1 sheet for each child

COMPETENCY MEASURE

TASK 1 (Objective 1): Give the child a piece of paper and a crayon. Say to the child, Draw a triangle. The child's figure should be a reasonable facsimile of a triangle.

TASK 2 (Objective 2): Give the child eight objects, such as cubes or discs, to use as markers. Draw a rectangle on the board and tell the child, Arrange the objects in the shape of the drawing. The child should arrange the objects in the shape of a rectangle.

Place before the child arrangements made with paper clips of a square, an ellipse, a triangle, a rectangle, and a circle.

TASK 3 (Objective 3): Say to the child, Point to the arrangement that is like an ellipse. The child should point to the ellipse.

TASK 4 (Objective 3): Point to the five arrangements made of paper clips, and say, Name the shape of each of these arrangements. The child will successfully perform this task if he names at least 4 of the 5 shapes.

Materials

Crayon, 1
Drawing paper, 1 sheet for each child
Objects, 8, such as cubes or disks (*Module 10*)
Paper clips, 1 box

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10 Using Space/Time Relationships/c

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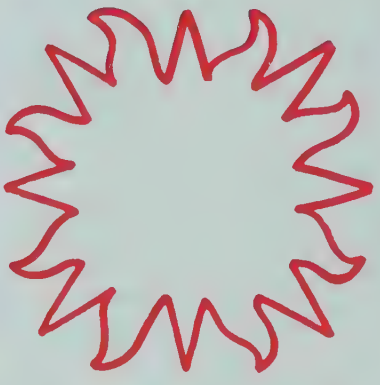

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SCIENCE... A PROCESS APPROACH II

MODULE

11

Observing/e

Listening to Whales

OBJECTIVES

At the end of this module the child should be able to

1. *IDENTIFY* and *NAME* the louder or softer of two sounds.
2. *IDENTIFY* and *NAME* the longer or shorter of two sounds.
3. *IDENTIFY* and *NAME* the higher or lower (pitch) of two sounds.
4. *IDENTIFY* a sound as being more like one of two dissimilar sounds.

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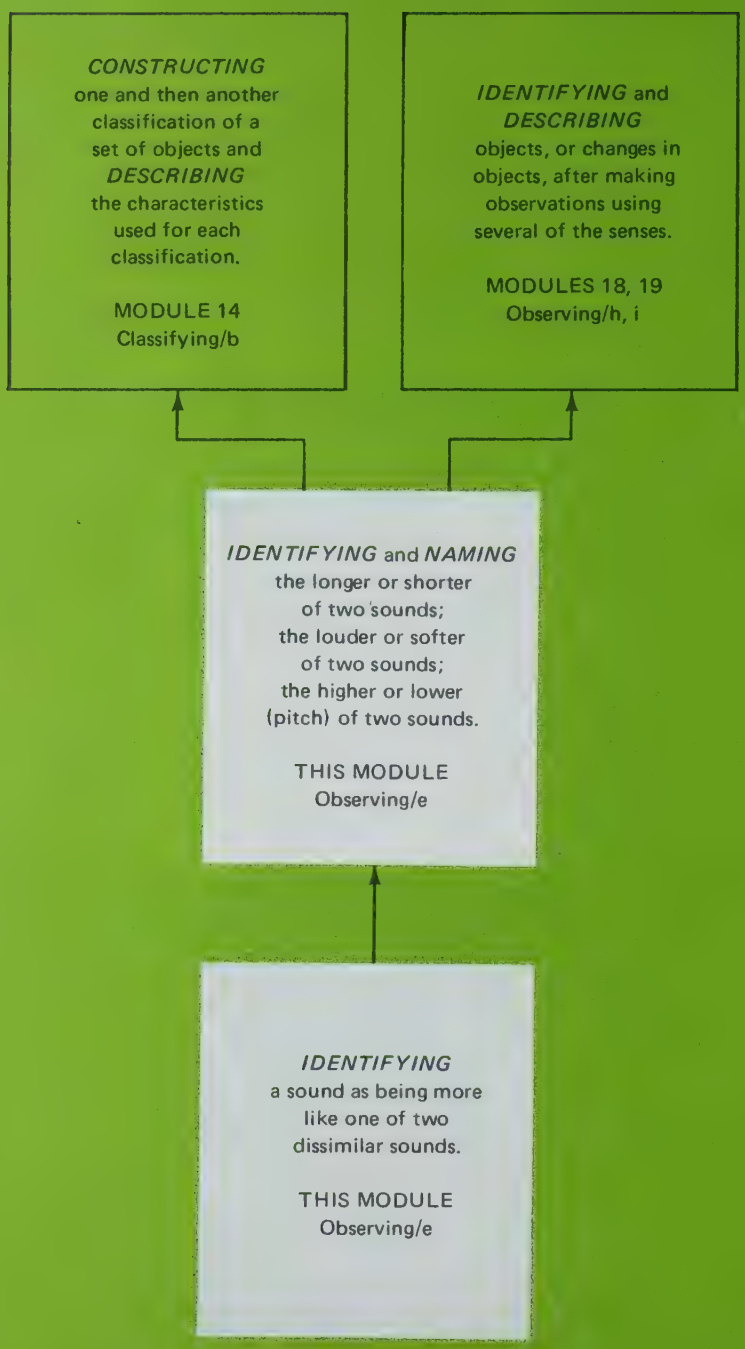
CONSTRUCTING one and then another classification of a set of objects and *DESCRIBING* the characteristics used for each classification.
MODULE 14 Classifying/b
IDENTIFYING and *DESCRIBING* objects, or changes in objects, after making observations using several of the senses.
MODULES 18, 19 Observing/h, i
IDENTIFYING and *NAMING* the longer or shorter of two sounds; the louder or softer of two sounds; the higher or lower (pitch) of two sounds.
THIS MODULE Observing/e
IDENTIFYING a sound as being more like one of two dissimilar sounds.
THIS MODULE Observing/e

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RATIONALE

In this module the children make observations by listening. Listening to sounds is a very important way of learning about one's environment. This module will help children become more aware of listening as a conscious process. Good listening habits are indispensable for learning.

Identifying and naming sounds is analogous to identifying and naming objects by sight. In the beginning, attention should be drawn to gross differences in sounds; for example, a car horn contrasted with the sound of running water. Later it may be appropriate to call attention to the subtle distinctions between the sounds of two different car horns or two different jet airplanes.

Sounds have at least four characteristics: duration (long or short), pitch (high or low), volume (loud or soft), and timbre (quality). The children will usually have little difficulty with the duration and volume aspects of sound. They should have little difficulty distinguishing sounds having widely different timbre, such as the ringing of a bell and the ticking of a clock. They may need practice to distinguish sounds of similar timbre such as a dime and a penny dropped on a hard surface. Some children can distinguish even small variations in pitch with ease. Others may have considerable difficulty identifying this property of sound. Be sure to visit with the music teacher about these activities. Together you will find additional opportunities for reinforcement.

In art activities, encourage the children to draw their own pictures of the whale world.

Vocabulary

sound	soft
silence	high
listen	low
hear	long
loud	short

INSTRUCTIONAL PROCEDURE

Introduction

Create the following deep-sea experience. Tell the children they are going to "listen in" on the world of whales in the deep blue sea. Darken the room and show the slide of the whale. Make up a story about a diver who descends into the ocean to learn about whales. If a story does not readily come to mind, you might use the following one.

MIGUEL AND THE WHALES

> Miguel was an adventuresome skin diver. One day, while he was diving in the sparkling blue ocean, he saw something large moving slowly below the rock ledge he was sitting on. As the "very-large-something" came closer, he saw that it was a large, beautiful whale. He hid behind a big rock and kept very still. Soon he heard the whale begin to sing a song. Listen to it now and pretend you are Miguel.

Let the children pretend that they are hiding behind large rocks in the ocean. Play about 30 seconds of the record *Whale Song* and project the colored slide of the whale. Suggest to the children that the whale may be "talking" to another whale and ask them what they think the whale is saying. Let them move and act out the parts of the whales.

Materials

Whale Song, 1 record (*Module 11*)
Slide projector, 1
Slide, 1, of whale underwater (*Module 11*)

Activity 1

Let the children continue to pretend they are whales. As they imitate the whale sounds, have them reach high when the sounds are high and low when the sounds are low. You might suggest that they hold their hands at shoulder height when a sound is between high and low.

Sketch three figures on the chalkboard showing children holding their hands for high, low, and in-between sounds. (See Figure 1.) Next sing or play high, low, and in-between sounds, and as you sing or play each sound, use the symbol in Figure 1 to indicate the pitch and duration of the sound. Ask the children to tell you why they think you made some of the lines long and some short. You might ask some of the children to draw lines on the board to represent the pitch and duration of sounds that you or the children sing or play.

After the children have developed some skill in doing this, draw a series of symbols on the board and ask the children to hum what you have drawn.

Activity 2

Play the record *Whale Song* and ask the children to trace, with their fingers in the air, the rise and fall of the whale's sounds. After the children have listened to the record, give each child a copy of *Song of the Whale* (Figure 2). Explain that the lines on the score match the whale sounds that the children have just heard. Play the song again and ask the children to trace with their fingers the lines on the paper that match the rise and fall of the whale's sounds. Stop from time to time if necessary to help them to follow the matching of "high" sounds with high marks on the score and of "low" sounds with low marks on the score.

Let the children practice listening to the sounds and tracing the marks on the score as long as the children continue to be interested.

Later, during story time, let the children make up and tell short stories about what the whales are "saying." Play portions of the record so they may interpret the sounds.

At some time during these activities it will be easy and appropriate to introduce your ideas and/or attitudes regarding endangered species, such as some whales.

Materials

Whale Song, 1 record (*Module 11*)
Song of the Whale, 30 copies, Figure 2 (*Module 11*)
(Note: the symbols on the song sheet are meant to approximately, not accurately, represent the sounds.)

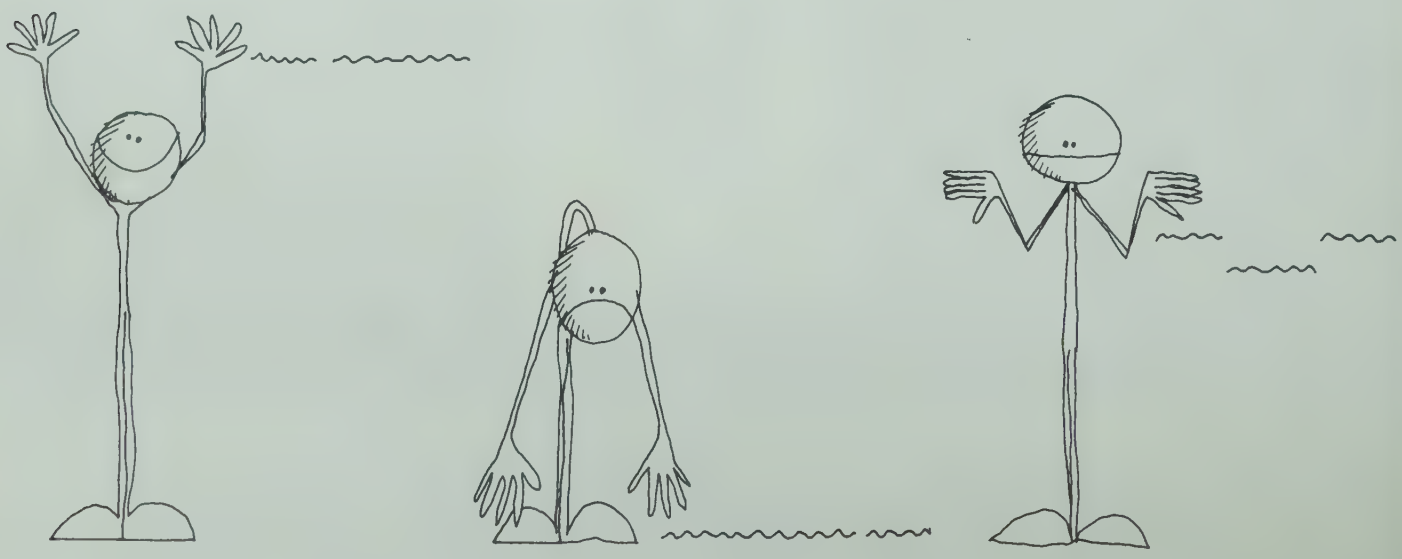

FIGURE 1

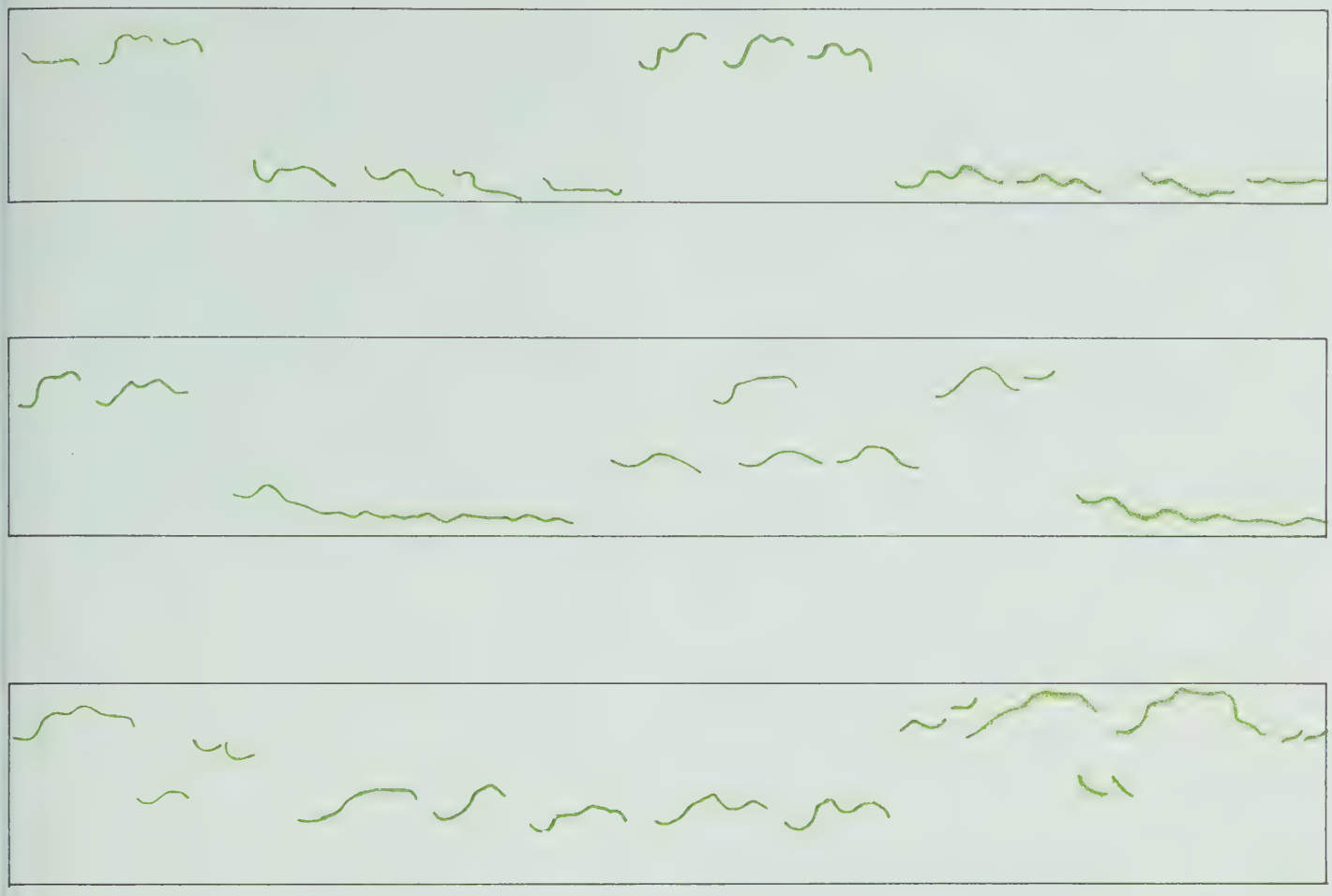

FIGURE 2

Activity 3

Tell the children to cup their hands over their ears and to press them gently but firmly against their heads. (See Figure 3.) Tell them to hum softly and to try to imitate the whale's song. The humming is greatly amplified and the sound seems to emanate from deep inside the skull. Some children will comment on how loud the sound seems to be.

Urge them to experiment with their humming technique. Opening and closing the mouth changes the sound. So does alternately pressing their hands to their ears and then taking them off. The children should discover that the sound seems louder when their hands are on their ears than when they are off. Ask the children to name some sounds that are loud (car horn, siren, shout) and some sounds that are soft (whisper, rubbing hands together, turning pages of a book).

FIGURE 3

Activity 4

Ring a hand bell and tap the desk with your knuckles. Ask the children to tell you about these sounds. They may say that the bell sound is higher than the tapping sound, that the bell sound is longer than the tapping sound, or that the bell sound is louder than the tapping sound.

Tell the children that you are going to make several sounds, and that you would like them to tell you whether each sound is like the bell or like the tapping and why they think so.

Drop a ball on the floor. Snap a finger. Whistle or hum a high note. Make other sounds. In every case, accept the child's classification if he gives a reason for it.

Materials

Hand bell, 1 (*Module 11*)
Rubber ball, 1 (*Module 9*)

Activity 5

Show the children a sheet of paper. (Typing paper or other smooth paper will do.) Ask them how many different ways they can make sounds with the paper. After the children have made some suggestions, give each child a sheet of paper and let him try making sounds with it.

Let the children experiment, but give them suggestions if they need help. These are some possible ways of making sounds with a sheet of paper:

1. Rub it across the desk with the fingertips.
2. Let it fall to the floor like a leaf.
3. Suspend it by one corner between the thumb and forefinger and shake it. (See Figure 4.)
4. Hold opposite corners between the thumbs and forefingers. Quickly pull the paper taut. (Of course you will have to be careful that you do not tear it.)
5. Tear the paper.
6. Crumple the paper into a ball.
7. Place the ball of crumpled paper on the table and listen to the sound as it expands slightly.
8. Drop the wad of crumpled paper on the floor.
9. Smooth out the crumpled paper with the fingers.
10. Hold the paper taut between slightly open lips and blow on it. (See Figure 5.)

Most of these are uncommon uses for a sheet of paper. Ask the children which of the noises they produced with the paper was the loudest. Ask them which one was the softest. Which sounds were long and which were short? Can high and low sounds be made with a piece of paper?

Materials

Typing paper, 1 sheet for each child

Generalizing Experience

Plan a walk along a route in the neighborhood of the school where unusual or interesting sounds are heard. Before you take the children out, ask them to listen (while they are walking) for high and low sounds, for loud and soft sounds, and for long and short sounds.

After the walk discuss the varieties of sounds the children have heard.

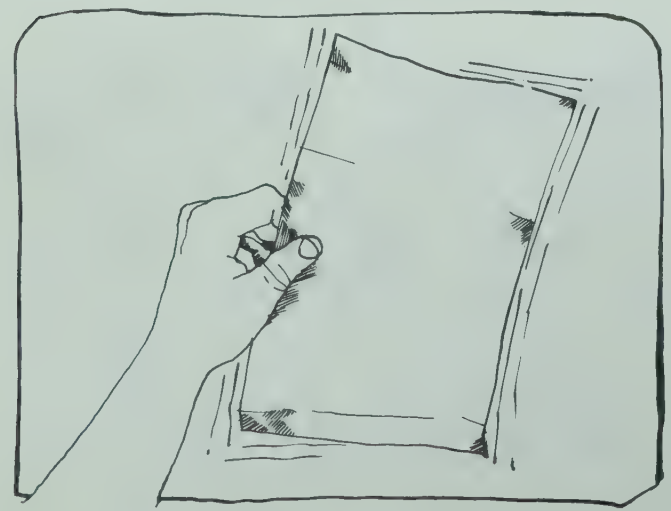

FIGURE 4

FIGURE 5

APPRAISAL

Tell the children that you are going to make two sounds and that you want them to tell you which is louder and which is softer. Then clap your hands and tap two pencils together.

Shake a piece of paper so that it rattles—first for about ten seconds, and then for one or two seconds. Ask the children what was different about the two sounds. (The first was longer than the second.)

Take two similar drinking glasses and add water to one until it is half full. Tap each of the glasses and ask the children what is different about the two sounds.

Rub your hands briskly together. Then write with chalk on the chalkboard and drop a coin on a table. Ask the children which of the last two sounds was most like the sound you made by rubbing your hands together.

Materials

Paper, 1 piece
Pencils, 2
Glasses, 2, drinking, similar
Coin, 1

COMPETENCY MEASURE

TASK 1 (Objective 1): Use a slide whistle to make variations in sounds. Show the child the instrument and then ask him to face the other way. Say, I am going to make two different sounds, one after the other. Tell me how the second is different from the first. Blow a note softly; after about three seconds, blow the same note loudly. Ask, How did the second sound differ from the first? The child should describe the second sound as being louder than the first.

TASK 2 (Objective 2): Say, Now I am going to make two other sounds. Tell me how the second is different from the first. Blow a note for three seconds; after a two-second pause, blow the same note for one second. Ask, How did the second sound differ from the first? The child should describe the second sound as being shorter than the first.

TASK 3 (Objective 3): Say, Now I am going to make two other sounds. Tell me how the second is different from the first. Blow a high note; after a three-second pause, blow a low note. Ask, How did the second sound differ from the first? The child should describe the second note as being lower than the first.

TASK 4 (Objective 4): Blow a high note, followed by a low note. Then ring a bell. Ask the child, Is the sound of the bell more like the first or more like the second sound I made? Repeat the sounds and the question. The child will complete this task successfully if he correctly identifies the sound according to the pitch of the bell.

Materials

Slide whistle, 1 (*Module 11*)
Hand bell, 1 (*Module 11*)

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11 Observing/e

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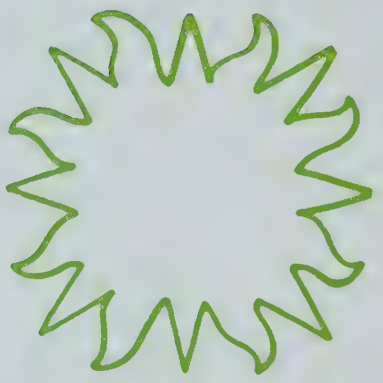

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SCIENCE... A PROCESS APPROACH II

MODULE 12

Using Space/Time Relationships/d

Three-Dimensional Shapes

OBJECTIVES

At the end of this module the child should be able to

1. *IDENTIFY* and *NAME* the following three-dimensional shapes: sphere, cube, cylinder, pyramid, and cone.
2. *IDENTIFY* and *NAME* the two-dimensional shapes that are components of regular three-dimensional shapes.

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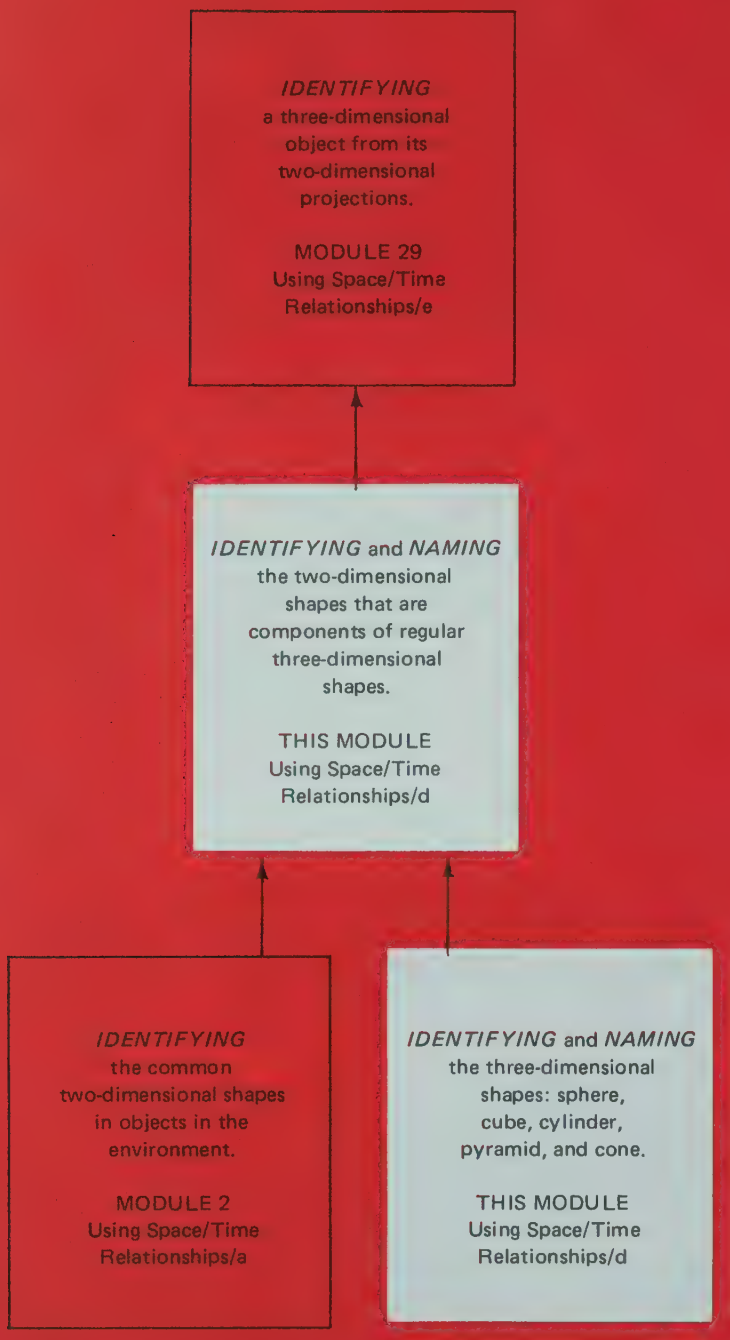
IDENTIFYING a three-dimensional object from its two-dimensional projections.
MODULE 29 Using Space/Time Relationships/e
IDENTIFYING and *NAMING* the two-dimensional shapes that are components of regular three-dimensional shapes.
THIS MODULE Using Space/Time Relationships/d
IDENTIFYING the common two-dimensional shapes in objects in the environment.
MODULE 2 Using Space/Time Relationships/a
IDENTIFYING and *NAMING* the three-dimensional shapes: sphere, cube, cylinder, pyramid, and cone.
THIS MODULE Using Space/Time Relationships/d

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0–663–29677–3

RATIONALE

This module introduces the child to three-dimensional shapes and to relationships among two-dimensional and three-dimensional shapes. The children should recognize these relationships early. The module builds upon the activities of *Recognizing and Using Shapes, Using Space/Time Relationships a, Module 2.* As in that module, it is important in this one to illustrate the shapes with many objects familiar to children.

In this module, such shapes as the triangle, rectangle, square, circle, and ellipse are called two-dimensional shapes; whereas such shapes as the cube, pyramid, sphere, cylinder, and cone are called three-dimensional shapes. Children can use the terms *two-dimensional* and *three-dimensional.* Later, they will learn that they need to make measurements in two directions to find the areas of two-dimensional shapes and in three directions to find the volumes of three-dimensional shapes.

You may wish to omit the pyramid, rectangular prism, and ellipsoid. The first and last are not common shapes, and *rectangular prism* may be too difficult a term.

Vocabulary

sphere	trace
cube	base
cone	two-dimensional
cylinder	three-dimensional
pyramid	ellipsoid

INSTRUCTIONAL PROCEDURE

Introduction

Place on a table in front of the room objects from the classroom, playground, home, or street that illustrate these three-dimensional shapes: sphere, cube, cone, cylinder, and pyramid. This will not be difficult to do except possibly for the pyramid. If you can *not* find a good example of a pyramid, do not introduce this shape until *Activity 1.* Possible items that might be used are:

sphere: balls of all types, ball bearing, marble
cube: sugar cube, children's block
cylinder: food can, tube, chalk
cone: ice cream cone, funnel
pyramid: metronome (sometimes a truncated pyramid), vase

If you like, also place pictures of objects representing the shapes, such as buildings, fuel tanks, tents, and the like, alongside the items. Here you can include the pyramids of Egypt.

Give the children plenty of time to walk around the table, examine the objects, and talk about them. When you think the children are ready, hold up one shape, perhaps a cube, and ask a child to describe it. He may use the name, *cube,* but if he does not, do not mention it at this time. Ask questions which will encourage the child to use the term *square* in describing the flat faces of the cube. Continue this type of discussion with a few more examples and then try a "question and answer" game. In this game one child thinks of an object. By asking the child a series of questions about the shape of the object, the children should be able to identify the object.

Materials

Objects, an assortment, of the shapes sphere, cube, cone, cylinder, and pyramid
Pictures, an assortment, of objects representing the shapes
Picture card, 1, of Egyptian pyramid (*Module 12*)

Activity 1

On a table adjacent to the display table set up for the previous activity, display the plastic sphere, cylinder, cone, cube, and pyramid and call the children's attention to them. Space these so that there will be room for the objects on the first display table to be placed next to or around the plastic shapes. Then ask each child in turn to pass around the two tables and select an object from the first table and place it beside the appropriate shape on the second table. As this is done, casually start using the names of the shapes by asking questions such as, Where are you going to place the paper cup? Next to the cone? Even though a child makes an error in his classification, do not correct it now. Some child will probably notice the error and make the correction at a later time.

When all of the objects have been placed, hold up the plastic cube and several of the cubic objects and ask for a show of hands of those who had used the term *cube*, and ask the children to repeat the term. Do the same for the other shapes. Tell the children that these are called three-dimensional shapes.

Ask them to look for other objects in the room that are like any of the shapes. You may wish to have a number of these around the room for this purpose. You may also wish to encourage the children to bring items from home that represent the shapes.

Repeat all or part of this activity a second day to be sure that the children learn to identify and name the three-dimensional shapes.

So far as vocabulary is concerned, you may introduce the names *cone, cylinder, pyramid,* and *ellipsoid* at whatever rate the class can assimilate them—perhaps one new term per day. Pictures of ice cream cones or nose cones of rockets, ice or sugar cubes (some ice cubes are not really cubes), and Egyptian pyramids help make the names meaningful. An ellipsoid may be related to an ellipse in the same way a sphere is related to a circle. If the children ask the precise name for a box shape, they may enjoy the terms *rectangular prism* or *rectangular parallelepiped.*

Put all the three-dimensional objects on a table in front of the room (see Figure 1) and play the game "What Shape Am I Thinking Of?" At first, phrase each question so it can be answered by "Yes" or "No," until the children can use the correct name of the shapes, saying for example, "It is a cylinder." Later, you can make the game more difficult by asking a child to describe a shape. Let him make statements such as this: "It looks like a triangle from the side, and it looks like a square from the bottom." Then ask for a volunteer who can tell what the first child described. If the volunteer picks up the correct shape, let him describe another shape for someone else to identify.

Materials

Objects, an assortment, used in previous activity
Plastic shapes, 7, one of each type: sphere and cube (*Module 3*), cylinder, cone, pyramid, ellipsoid, and rectangular prism (*Module 12*)

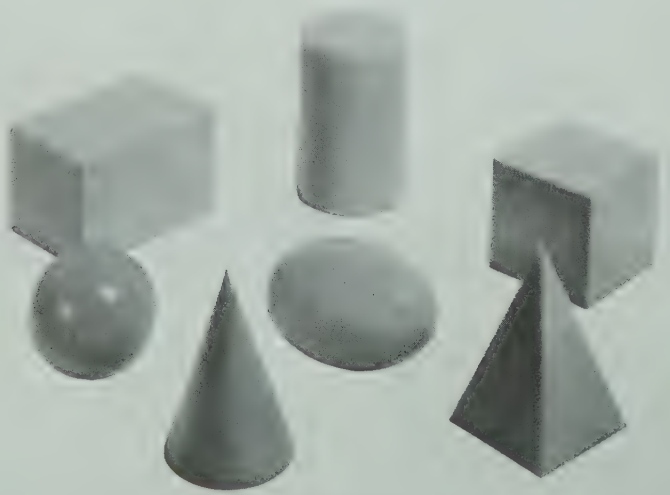

FIGURE 1

Activity 2

Place the following three-dimensional shapes approximately 40 centimeters apart on a chalk tray: a cone, cylinder, ellipsoid, cube, pyramid, rectangular prism, and sphere. Place the two-dimensional cut-out board next to the shapes. You may wish to use the following suggested directions.

"Pick up one of the three-dimensional shapes on the chalk tray. Find a two-dimensional shape on the shape that you selected. Now, find your two-dimensional shape on this board. (Point to the board with cut-outs.) See if you can fit the three-dimensional shape into the cut-out you found on the board. If the three-dimensional shape fits, put it back on the chalk tray and over it draw on the chalkboard the

two-dimensional cut-out you found. If the three-dimensional shape does not fit, look for another cut-out on the board that it will go through. Then place the three-dimensional shape back on the chalk tray and draw over it on the chalkboard the shape of the cut-out it fits through."

After a child fully understands the procedure, he can show another child how to play. Hence, this activity becomes peer-instructional. After the children have completed this procedure, you will have a record of their responses on the board. If the children can write their names or initials of their names, you might wish to have them mark their drawings on the chalkboard to enable a quick check.

After all of the children have tried this activity, they might participate in a modified "spelling bee," a "2D-3D-bee." Point to one of the two-dimensional cut-outs on the board and have a volunteer find a three-dimensional shape to fit it. If he misses, he has to sit down..

Thus far in this activity, the children have been identifying two-dimensional shapes on the supplied three-dimensional objects. The children will now identify two-dimensional shapes on other objects. Place in the classroom a collection of shapes such as a chalk box, a cigar box, a die, an ice cream cone, a soda can, and a basketball. Ask a child to select a three-dimensional shape and have him hold it up. Ask the class to name the three-dimensional shape. Then ask individual children to name the two-dimensional shapes that they see on the three-dimensional shape. Repeat this procedure or a variation, if one is suggested during the discussion, with all of the three-dimensional shapes you have chosen to introduce in your class. When children make errors help them correct false impressions, if the responses are "far off."

When the ice cream cone is held up the children will mention the circle, and some may say they see a triangle. If they have difficulty identifying the triangle, hold the ice cream cone next to the chalkboard and trace around its edges. Remove the ice cream cone and ask the children what shape they see on the board. This same procedure may be helpful in identifying the rectangle associated with a cylinder. (See Figure 2.)

Give each child a three-dimensional shape and ask him to draw on paper a two-dimensional shape that he sees on the three-dimensional shape. Ask the children to form groups of three so that they can check each other's drawings.

(If some children have difficulty with the activity, do not be too concerned. They will have other opportunities to acquire these skills in later modules.)

Materials

Plastic shapes, 7, one of each type: sphere and cube (*Module 3*), cylinder, cone, pyramid, ellipsoid, and rectangular prism (*Module 12*)

Board, 1, with cut-outs of two-dimensional shapes (*Module 12*)

Shapes, a collection, such as a chalk box, a cigar box, a die, an ice cream cone, a soda can, and a basketball

Drawing paper, 1 sheet for each child

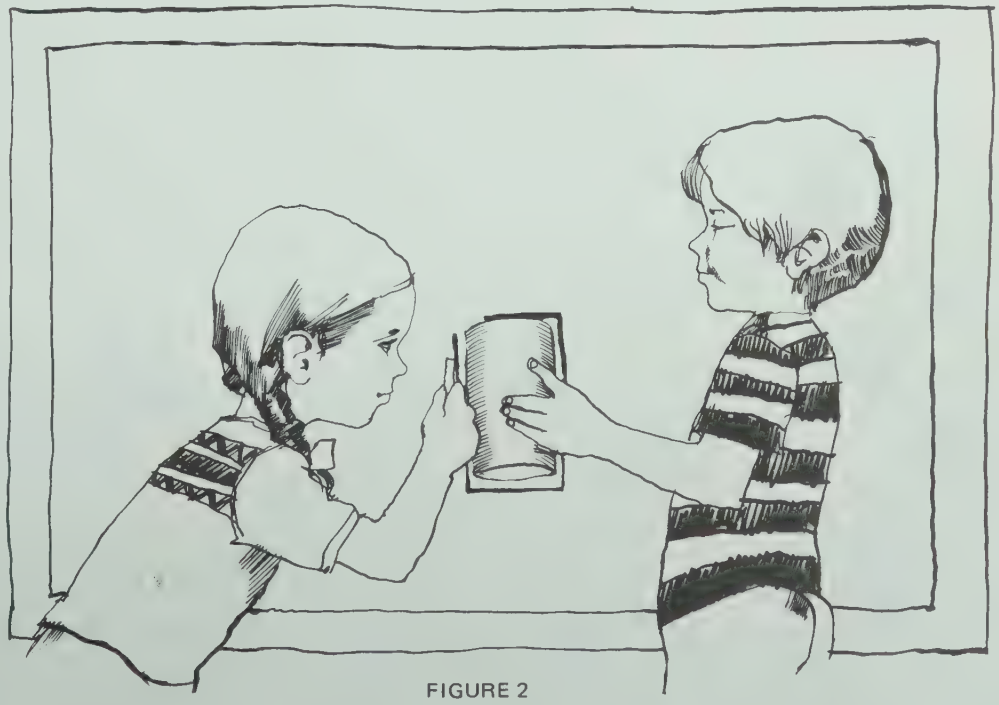

FIGURE 2

Activity 3

In *Activity 2* the children learned to identify and name two-dimensional shapes on three-dimensional objects. In this activity the children will observe another relationship between two-dimensional and three-dimensional shapes—namely, that three-dimensional shapes appear when two-dimensional shapes are rotated.

Hold up a sphere to begin discussion. Ask the children what two-dimensional shape they see on the sphere. Once the response of circle has been made, hold up the circle. Now, turn the sphere 90° and ask the class what two-dimensional shape they now see on the sphere. Turn the sphere slightly again and ask the class the same question. Suggest that if a circle appeared every time the sphere was turned, the sphere might be made of circles, or made by a spinning circle.

Use one of the following methods to demonstrate the generation of a three-dimensional shape by rotating a two-dimensional shape. Spin a cardboard disk using the technique shown in Figure 3. Punch two holes about two centimeters apart near one edge of the disk and a similar pair of holes near the opposite edge. Put a loop of string through each pair of holes, wind up the strings and pull, releasing the tension on the string when it is unwound so that it will wind up again in the opposite direction. By alternately increasing and decreasing the tension on the strings, you can make the circle spin rapidly first in one direction and then in the opposite direction. If you do this rapidly, the children should be able to see a spherical shape.

An alternative method of spinning a circle is to fasten it to a rod that can be clamped tightly into the chuck of a hand drill or power drill. (See Figure 4.) When the drill is turned on, the rapidly rotating circle will look like a sphere.

If the children are interested, you might use other shapes to show how a triangle can generate a cone; a rectangle, a cylinder; and an ellipse, an ellipsoid.

Materials

Sphere, 1, plastic (*Module 3*)
String, 1 piece, about 1 meter (*Module 6*)
Rod, 1 (*Module 8*) (optional)
Hand or power drill, 1 (optional)
Cardboard shapes, 4, one of each type: circle, triangle rectangle, and ellipse (*Module 2*)

FIGURE 3

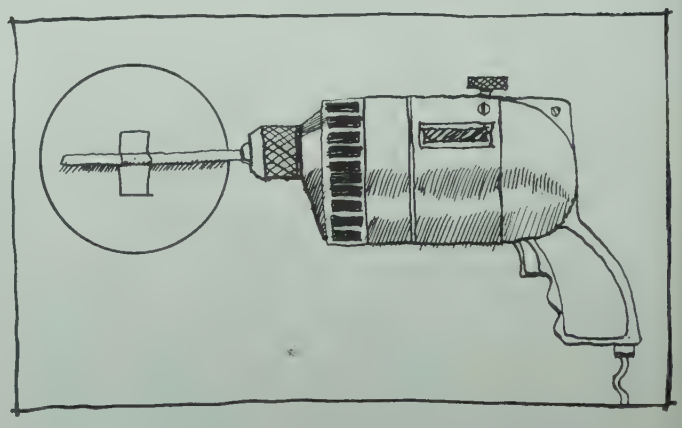

FIGURE 4

APPRAISAL

Have the children take turns matching the three-dimensional plastic shapes with two-dimensional shapes made of colored paper. For each three-dimensional shape, there may be more than one related two-dimensional component. For example, a child might place a plastic cone on either the paper circle or triangle. Encourage the children to bring three-dimensional objects from home to enlarge the display.

Have the children play "Touch and Tell." From a box filled with the plastic shapes, have a volunteer select a shape and hand the shape to a blindfolded child. Ask the second child to identify the shape and explain how he identified it. You can make the game more difficult by asking the blindfolded child to hand the other child a specific shape from the box.

Materials

Plastic shapes, 7, one of each type: sphere and cube (*Module 3*), cylinder, cone, pyramid, ellipsoid, and rectangular prism (*Module 12*)
Objects, an assortment, of the three-dimensional shapes studied
Colored-paper shapes, 10 or 15, large, two or three of each type: square, circle, triangle, rectangle, and ellipse
Blindfold, 1

COMPETENCY MEASURE

Give the child the following collection: a piece of string, a party hat (cone-shaped), a rubber ball, a piece of metal pipe, a Christmas tree ornament (sphere-shaped), a cube of sugar, a funnel, and a picture of an Egyptian pyramid. (You may substitute other objects, if you wish.)

TASK 1 (Objective 1): Say to the child, Pick up something that has the shape of a cone. The child should pick up either the party hat or the funnel.

TASK 2 (Objective 2): Tie a string around the outside of the sphere. Ask, What do we call the shape made by this string? The child should answer "circle."

TASK 3 (Objective 1): Point to the pipe and say, What is the shape of this pipe? The child should say "cylinder."

TASK 4 (Objective 2): Say to the child, One of these three-dimensional shapes has a square on it. Point to the shape and to the square on it. The child should point to the sugar cube and to the square on one side of the cube.

Materials

String, 1 piece, about 30 cm long (*Module 6*)
Party hat, 1, cone-shaped (*Module 9*)
Ball, 1, rubber (*Module 9*)
Pipe, 1 piece, metal
Ornament, 1, sphere-shaped, Christmas
Sugar, 1 cube (*Module 7*)
Funnel, 1
Picture 1, of Egyptian pyramid (*Module 12*)

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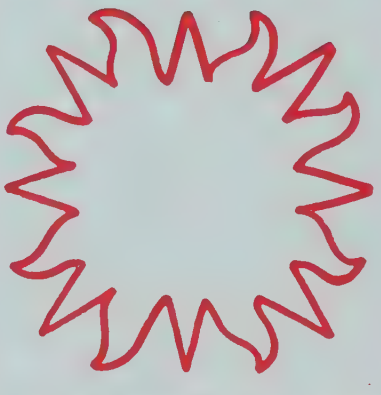

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SCIENCE... A PROCESS APPROACH II

MODULE

13

Using Numbers/b

Numerals, Order, and Counting

OBJECTIVES

At the end of this module the child should be able to

1. *IDENTIFY* and *NAME* the order position of any object or event in a sequence of five objects or events, using the numerals *1, 2, 3, 4,* and *5* and the ordinal names *first, second, third, fourth,* and *fifth*.
2. *IDENTIFY* and *NAME* the number of members of a set from 0 to 12 using a written numeral and the number word.
3. *ORDER* sets which have 0 to 12 members.
4. *DESCRIBE* an item in a sequence as being between two other items in the sequence by saying, for example, "The third item is between the second and fourth."

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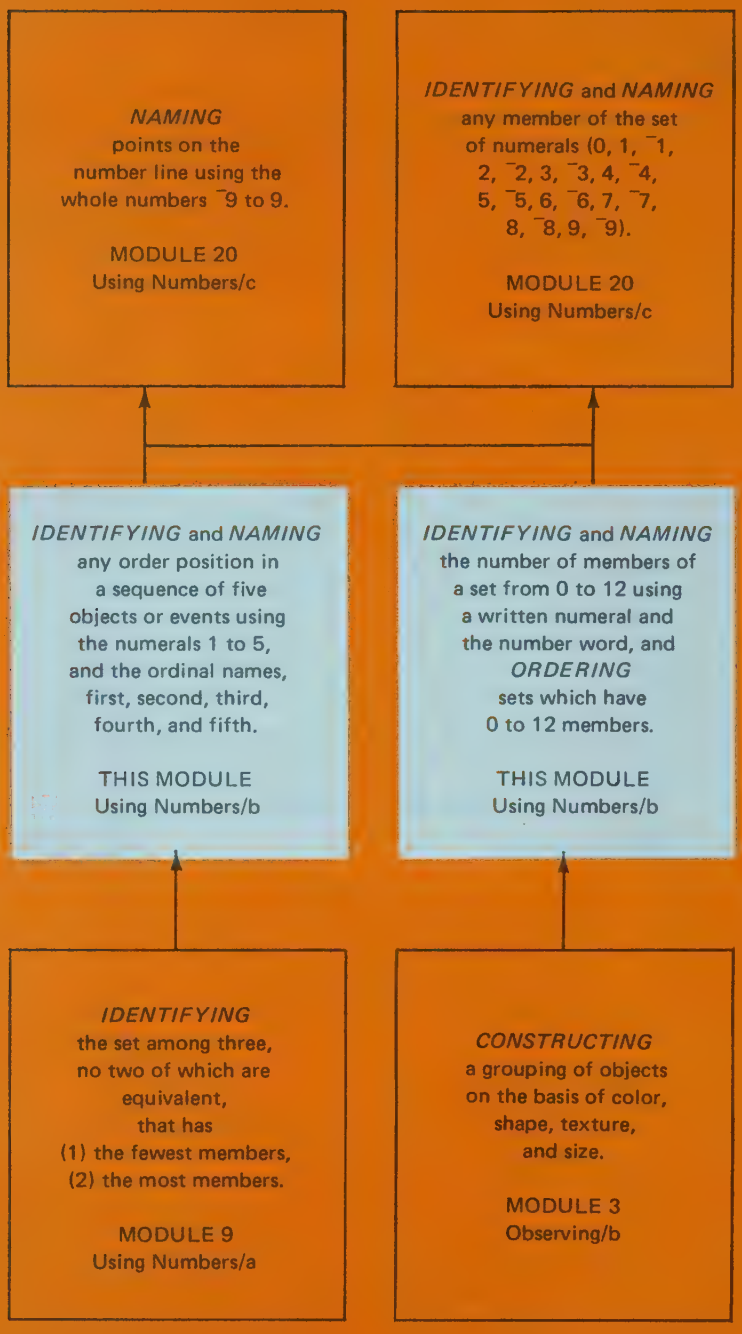
SEQUENCE


NAMING
points on the number line using the whole numbers ¯9 to 9.
MODULE 20
Using Numbers/c
IDENTIFYING and *NAMING*
any member of the set of numerals (0, 1, ¯1, 2, ¯2, 3, ¯3, 4, ¯4, 5, ¯5, 6, ¯6, 7, ¯7, 8, ¯8, 9, ¯9).
MODULE 20
Using Numbers/c
IDENTIFYING and *NAMING*
any order position in a sequence of five objects or events using the numerals 1 to 5, and the ordinal names, first, second, third, fourth, and fifth.
THIS MODULE
Using Numbers/b
IDENTIFYING and *NAMING*
the number of members of a set from 0 to 12 using a written numeral and the number word, and *ORDERING* sets which have 0 to 12 members.
THIS MODULE
Using Numbers/b
IDENTIFYING
the set among three, no two of which are equivalent, that has (1) the fewest members, (2) the most members.
MODULE 9
Using Numbers/a
CONSTRUCTING
a grouping of objects on the basis of color, shape, texture, and size.
MODULE 3
Observing/b

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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0–663–29683–8

RATIONALE

Children may achieve the objectives of this module in their mathematics program. You first should determine if the children have the skills described in the objectives. If they do not have these skills, you may want to teach this module as a supplement to the regular mathematics program. If they have these skills, you might use the module for maintenance.

At the beginning of the module it is assumed that children can identify and name the number of members of a set of as many as five members. If some of your children do not have this skill, you should help them to acquire it before you teach the module. Then in *Activities 3, 4,* and *5,* the children will learn to identify the number of members of a set of as many as 12 members.

In the *Introduction* and *Activities 1* and *2* the children use numbers and their numerals to describe order, or rank. Although only a few examples are suggested here, many others can be used. Opportunities to use ordinal numerals will arise all during the school day and throughout the year. For several days, for example, you can call the children in a specific order to do certain tasks by using statements, such as Jane may be third, John should be fifth, or Mary should be second. Elementary ideas of "betweenness" are also introduced, as indicated in Objective 4.

The ordinal words *first* through *fifth* are usually not taught in kindergarten. They are introduced here because of the advantage of using them in many of the later modules which involve ordering. If the children can write the numerals, they should be encouraged to do so; but writing numerals is not a requirement at this time. Also, if children know additional ordinal names, such as *seventh* and *tenth,* encourage them to use these words, even though this is not a requirement of this module.

In this module the children explore the meaning of "number" and "counting." As it is developed here, counting uses the concept of a unit successor. By describing "two" as "one more than one," or "ten" as "one more than nine," the child is establishing a rational basis for identifying, as well as naming numbers in a counting sequence. By coupling the use of the unit successor with the concept of grouping by tens, the child should have little difficulty in later modules as he learns to count to 100.

Vocabulary

two	ten	second
three	eleven	third
four	twelve	fourth
five	zero	fifth
six	one more than	next to
seven	one less than	order
eight	empty set	
nine	first	

INSTRUCTIONAL PROCEDURE

Introduction

Ask five children to form an imaginary train in front of the class. Give each child a card on which one of the numerals *1, 2, 3, 4,* or *5* is printed. Tell the five children you selected to take places so that the numerals they are holding are in (numerical) order. Help them only if they have difficulty. Ask why they have arranged themselves in their particular order. If no one suggests that the numerals put them in a certain order, have the children exchange their numerals and ask them if their order is the same, since the same children are involved. Repeat the activity so that the numerals are sometimes *1* to *5* from left to right, and sometimes *1* to *5* from right to left.

Put several articles in a straight line on the demonstration table and ask two children to place their numeral cards below the articles in order from one side of the table to the other.

Materials

Numeral cards, 5, large, numbered 1-5, one card for each numeral (*Module 13*)
Objects, 5, from classroom

Activity 1

You should choose from the following procedures those that you think will be of most interest to your children.

1. Ask some children to order their families according to first-born, second-born, third-born, and so on. Draw or put up pictures of families with the appropriate numerals opposite the members. Or have the children make families from magazine cutouts, order the members by age, and place appropriate numerals next to the members. Choose pictures which allow no (or little) question about order of age from youngest to oldest.

2. Show the children page numbers in books and numerals on a calendar and tell them that they describe the order of pages and of days. Ask them to suggest other examples. Then read five pages of a story book in some random order to demonstrate the usefulness of proper order.

FIGURE 1

3. On the chalkboard or flannel board, place pictures with their accompanying numerals as illustrated in Figure 1. Ask questions about the animals and their ordinal positions.

4. Give each child a copy of *Coloring Squares* (Figure 2). As a first step, ask the children to cover the squares (color them or draw pictures on them) according to your instructions. For example, you might tell them to color the first square red, the second square blue, the third square brown, and so on. After they have covered the squares in the first row, ask the children questions such as:

Which square is red? (The first.)

Which square is blue? (The second.)

In which position are the red and brown squares? (The first and the third.)

Where is the blue square? (Second.)

How else could you describe its position? (It is between the red one and brown one—between the first and third.)

For the second and subsequent rows, vary the order of your instructions. For example, you might tell them to color the first square red, the third square brown, the fifth square yellow, and so on. If stickers are available, give these to the children to paste on some of the squares.

Materials

Drawing paper, 1 sheet for each child
Pictures, 30, of families
Calendar, 1
Books, several
Flannel board, 1 (Optional)
Picture cards, 5, cat, dog, bird, snake, and rabbit (*Module 13*)
Numeral cards, 5, large, numbered 1-5, one card for each numeral (*Module 13*)
Coloring Squares, 1 spirit master (*Module 13*)
Crayons, 1 box for each child

Activity 2

After the children are familiar with the ordinal number words, encourage them to talk about the sequence of objects which are arranged in a specific order. Have them use the phrase "next to the largest" when they are referring to size, "next to the longest" when they are referring to length, and similar phrases, such as "the next to the smallest" or "the next to the shortest." When there are five objects arranged in order by size, try to get them to say "the fifth in order is largest" and "the fourth is next to the fifth, or next to the largest." Provide a variety of other questions, such as Which window is first? Which table is this one? so that the child hears or says the five new ordinal words and gives answers about "betweenness." Expect him to say, for example, that the fourth is next to the fifth (or the third) and between the third and the fifth.

The children should have an opportunity to talk about "betweenness" on two or three days before this module is completed. When the children are in a line, ask them which children are between John and Mary. Then ask them which child is between the first and third child. Ask that child what his order is in the row. Follow with similar questions and other objects.

If the children are ready to use ordinal words and to talk about "betweenness" with more than five objects, by all means give them an opportunity to do so. However, for most young children, this activity probably carries these ideas far enough.

Materials

Objects, 10 or more, from classroom

Activity 3

1. Call the children's attention to sets of objects (including people) in the room with any number of members up to 12. For example, you might ask the children in the room with the name Mark to stand, and then ask how many members are in this set. Stress that the number (perhaps one, in this example) is the common property of all other sets with that number of members.

Continue this development with other collections of objects and have the children name the number of members of each set. *Zero* is the number of the empty set, the set that has no members (the set of elephants in the room). While other classroom activities are in progress, stop the children from time to time and have them name the number of children who are painting, playing with blocks, playing in the doll house, working with the puzzles, listening to records, and so on.

2. Arrange blocks (or rocks, leaves, or other objects) on the table. Pick out a set of two objects and ask a child to make a set of one more member than your set. Encourage him to use sentences, such as This set has five members, which is more than four members. Repeat this procedure with other sets with more members.

3. Arrange a group of 78 objects in sets containing from one to twelve members. (Seventy-eight is the sum of the numbers one through twelve.) Ask a child to select a set of objects with one member. Then ask the others whether anyone can find a set of objects with one more member. Next, have the child identify a set which has one more than two members. Continue this activity up to sets of twelve members. Call attention to the ordered place of the empty set.

Repeat the activity starting with the set of twelve members. Ask a child to select a set of objects which has one less than twelve members. Continue with sets of objects to the one with zero members.

4. Describe certain sets in the classroom and then have the children describe other sets of one more or one less than the number of members of the set you describe. For example, you might ask one child to identify a set of four members, a second child to identify a set of one less member, and a third child to identify a set of one more member.

Materials

Blocks, 5 or more, or rocks, leaves, or other objects
Objects, 78, from classroom

Activity 4

1. Give the children several sets of blocks. Have them describe each set in terms of its number, one more than a number, and one less than a number. For example, a set of blocks may be described as a set of three blocks, a set with one more than two blocks, or a set of one less than four blocks. Repeat with other objects and come back to this activity on several subsequent days.

2. Have the children group themselves into sets. You may do this either in terms of how many can stand in geometric shapes of string taped to the floor such as those in Figure 2, or in terms of eye color, color of clothing, hair color, or height. Tell them to count the number of children in each set and to describe the order of the numbers in terms of one more than or one less than.

A child might then describe the number of children in the square set as one less than the number in the rectangle, and the number in the triangle as one less than the number in the circle.

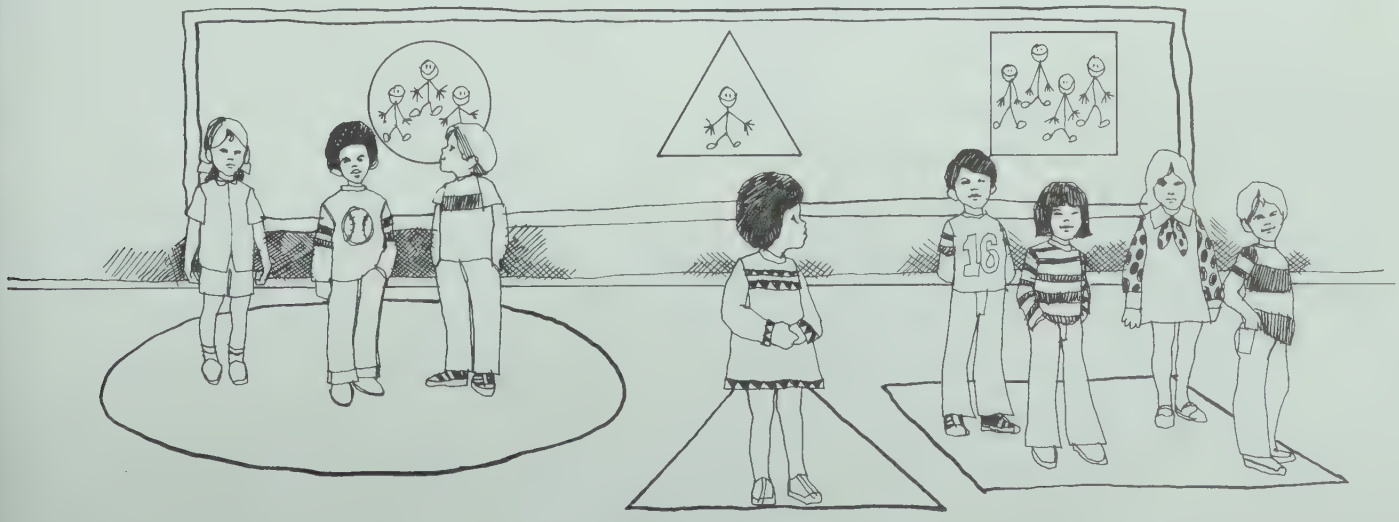

FIGURE 2

3. Arrange sets with one, three, and four members. The set with two members is missing. Have the children identify and describe the missing set by naming as the number of members and one less, or more than, than the number of members. The children might stand in geometric shapes as in Figure 3.

4. Further practice might include a mystery number game. Begin with the question, What mystery number am I thinking of? The children should ask questions, such as Is it five? Is it one more than nine? Is it one less than one?

Materials

Blocks, 10 or more (*Module 3*)
Tape, 1 roll
String, 1 ball (*Module 10*)

Activity 5

Display sets with different numbers of members and associate the appropriate written numeral with each set. On a table place a card with the numeral *1* along with several sets of one member. Similarly, place a card showing the numeral *2* with sets of two members, and so on up to 12. You could also use pictures and numerals on the chalkboard or flannel board.

Later, remove the numeral cards and ask groups of children, or individual children, to place numeral card 3, for example, with a set of three members.

To provide more practice, ask a child to come to the front of the room and to hold a card with a numeral *5*. Call five children by name to join him. Ask those still seated to describe the set of children at the front of the room in three ways. Three possible ways are "six," "one more than five," and "one less than seven."

Materials

Numeral cards, 12, large, numbered 1-12, one card for each numeral (*Module 13*)
Objects, 78 or more, from classroom

Generalizing Experience

1. Tell a story, such as "Jack and Jill," in which the events can be listed in order. For example, (1) Jack and Jill went up the hill; (2) they drew a pail of water; (3) Jack fell down; and so on. Show the picture cards that illustrate the story. The pictures could be laid out on a table after the story is told, and the children asked to order them, using the words *first, second,* and so on.

Ask Joe to pick up a book. Then ask him to give it to Susan. Ask Susan to show a picture in the book to Linda and ask Linda to give the book to you. See if the children can order these events using the words *first, second, third,* and *fourth.* You should use many other examples as well.

2. Select a set of four objects. Tell the children to describe this set in at least three ways. "A set of four members," "a set of one more than three members," and "a set of one less than five members" are three possible ways. Next ask if some other names can be used for this set. If they cannot think of any, you might suggest these:

1. A set of two more than two members.
2. A set that has two members less than six members.
3. A set with three more than one member.
4. A set of three less than seven members.

Select another set of objects. Tell the children to describe the set in terms of two more than, two less than, three more than, and three less than. This activity, of course, is an introduction to addition.

Materials

Picture cards, 5, for story "Jack and Jill" (*Module 13*)
Book, 1
Objects, 12 or more, from classroom

APPRAISAL

1. Draw pictures of sets having one, two, three, and four members on the chalkboard. Ask the children to call out the number of objects in each set as you point to it.

2. Give each child twelve objects (paper clips, pebbles, toothpicks, or whatever is convenient). Have him put these into sets containing one, two, three, and four members. Then ask him to order the sets by putting them into a sequence in a row.

3. Write a numeral from one to twelve on the chalkboard. Ask a child to bring you a set of that many objects. Write other numerals on the chalkboard and ask other children to bring you sets of these numbers of objects.

4. Arrange the chairs in rows having four or five chairs in each row. After the children are seated, ask the children who are third in each row to stand. Then ask those in the first position in each row to stand. Continue this until all of the children have responded.

Give the children in one row numeral cards to name their positions. Ask questions such as these:

who is first in the row?

Who is fourth in the row?

Who is between the first and the third in the row?

Who is next to the third in the row? (Second and fourth.)

Then ask the children who have the numeral cards to give them to the children in another row. Of course, be sure that the numeral cards are in order in the new row. Then repeat the activity with similar questions.

Materials

Objects, 12 for each child, such as paper clips, pebbles, or toothpicks
Numeral cards, 6, large, numbered 1-6, one card for each numeral (*Module 13*)

COMPETENCY MEASURE

Place before the child five books in a row, ordering them according to the number of pages. However, do not tell him, unless he asks, what the basis of the ordering is.

TASK 1 (Objective 1): Say, Give me the book in the "4" position. The child should give you the book in the fourth position for the correct response.

Place the books in order with an appropriate numeral card above each book.

TASK 2 (Objective 1): Say, Give me the third book. The child should give you the correct book.

TASK 3 (Objective 1): Pick up the fifth book and say, Which book is this? The child should say it is the fifth. If he says it is the last or the biggest, ask him for another name, and if he then says "fifth," the response is acceptable.

TASK 4 (Objective 4): Point to the second book in this sequence and say, This is the second book. Between what two books is it? The child will give an acceptable response if he says that the second book is between the first and third.

Put two stacks of books on the table: one of six books and one of three books. Also put on the table numeral cards for 0 to 12.

TASK 5 (Objective 2): Say to the child, How many books are in each of the stacks? Give me the numeral card for the number and also say the number for each pile of books. In order for a completely acceptable response, the child should give four correct answers.

TASK 6 (Objective 2): Give the child twelve crayons. Write the numeral *11* on the chalkboard or on a piece of paper. Tell the child, Bring me this many crayons. Point to the *11* as you say this. The child should give you eleven crayons.

TASK 7 (Objective 3): Give the child eight crayons, seven paper clips, and six pieces of paper. Say, Order the sets of crayons, paper clips, and pieces of paper. The child will complete this task successfully if he orders the sets correctly.

Materials

Books, 5, each with a different number of pages
Numeral cards, 13, small, numbered 0-12, one card for each numeral
Books, 9, of any number of pages
Crayons, 12
Paper clips, 7
Paper, 6 pieces

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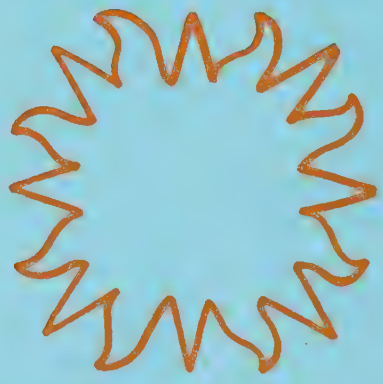
13 Using Numbers/b

SCIENCE...



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SCIENCE... A PROCESS APPROACH II

MODULE

14

Classifying/b

ALTERNATE TOPICS:

Animals
Familiar Things

OBJECTIVES

At the end of this module the child should be able to

1. *CONSTRUCT* a classification of a set of objects into two or more groups depending upon whether the objects can or cannot be used in a stated way.
2. *CONSTRUCT* another classification of the same objects, and *DESCRIBE* the characteristics used to classify the objects.

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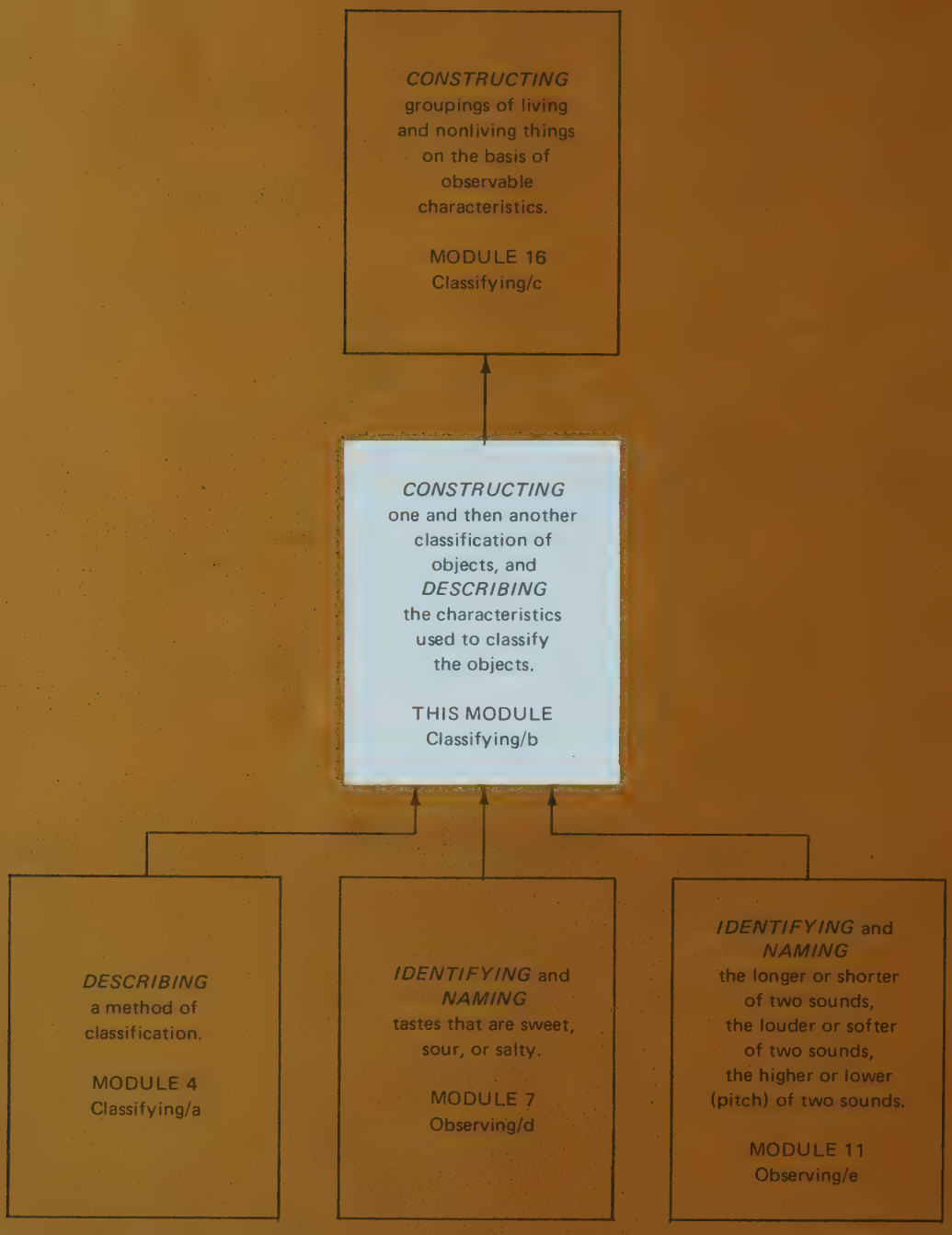
SEQUENCE


CONSTRUCTING
groupings of living and nonliving things on the basis of observable characteristics.
MODULE 16
Classifying/c
CONSTRUCTING
one and then another classification of objects, and *DESCRIBING*
the characteristics used to classify the objects.
THIS MODULE
Classifying/b
DESCRIBING
a method of classification.
MODULE 4
Classifying/a
IDENTIFYING and *NAMING*
tastes that are sweet, sour, or salty.
MODULE 7
Observing/d
IDENTIFYING and *NAMING*
the longer or shorter of two sounds, the louder or softer of two sounds, the higher or lower (pitch) of two sounds.
MODULE 11
Observing/e

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

In this module, as in *Leaves, Nuts, and Seashells, Classifying a, Module 4,* alternate topics are presented. You should choose one or the other. In the first topic, *Animals,* the children use several senses to observe animals and group them on the basis of similarities and differences. In the second topic, *Familiar Things,* the children classify objects according to how heavy they are (would the child want to carry them home?) how large they are (could the child carry them in a paper bag?) and in other ways.

Living animals help children become familiar with some stages in life cycles, although life cycles are not discussed here. Observable similarities and differences between parents and their young and between parents themselves provide a base for later study of the growth, development, and reproduction of animals.

Some teachers of young children prefer limiting the number of live animals in the classroom at a given time to two instead of the suggested three. If you do use two, adjust the activities accordingly.

In classifying familiar things, give each child an opportunity to take objects from a large set and put them into appropriate subsets. Avoid directing the choices. Trials followed by discussion will give the children the experience needed to construct valid classifications.

Classification schemes are used in science for many purposes. For example, in biology, plants and animals are classified to show relationships and to simplify their identification. And in chemistry, elements and compounds are classified to show similarities of chemical reactivity.

Vocabulary

classify classification

INSTRUCTIONAL PROCEDURE

Alternate Topic: Animals

Introduction

Have three living animals (see *Materials*) in the room for the children to observe and touch. Two of the animals should be from one group, with the third from a different group. We suggest a kitten, a hamster, and a grasshopper, but you may use others if they are easier to get.

Bring all three animals in front of the group. However, keep the animals in separate glass jars or cages. (See Figure 1.) Ask the children such questions as these:

Which of these animals do you know the most about?

What things do you know about that animal?

How did you find out these things about that animal?

Take the kitten from the cage, and suggest that the children use their eyes and ears to find out all they can about kittens which they had not known before. Invite the children to come into a tightly closed circle on the rug or floor. Hold the kitten so they can see its feet, ears, and teeth. Allow the kitten to move around on the floor. Then help the children to describe what they see and hear.

Invite a few children at a time to touch the kitten. Give all those a turn who want one. Ask whether there are other things they would like to know about the kitten or to look for.

In turn, bring each of the other two animals into the group, and let the children touch them and describe what they see, hear, and feel. Ask the children to put together in one group the two animals (still in separate cages) that are the most alike. Discuss with them why these two are alike

FIGURE 1

and the other different. If there is disagreement among the children, discuss all possibilities freely. Do not insist that there is only one correct way.

Put picture cards of the three animals observed on the bulletin board for use in *Activities 1* and *2*.

Materials

Animals, 3, live
Note: Choose two animals from one group and the third from another group.
1. Hen, parakeet
2. Dog, kitten, rabbit, hamster
3. Butterfly, bee, grasshopper

Cages, 3, for animals
Picture cards, 3, illustrating the three animals chosen (*Module 14*)

Activity 1

Show the children another live animal—perhaps a rabbit, a hen, or a butterfly. Then help all the children observe and describe it. Encourage them to handle the animals freely so long as they and the animals are not endangered. However, do not insist that any child touch or handle an animal if he seems unwilling to do so.

Show the children a picture card of the same animal, and ask them to group the card with the picture cards on the bulletin board. Suggest that they arrange the four pictures in sets. You could ask individual children to take turns in doing this and to explain the basis of the classification. Let the other children help the child who is arranging the pictures if necessary.

Show other picture cards one at a time and ask individual children to place them in the appropriate set. After five or six pictures have been classified, mix them and have them classified differently according to a characteristic named by another child.

If after several classification schemes have been used, none has been based on a use of the animals, ask the children to suggest uses of the animals that might be considered. Possibilities include: as pets, for food, for food production (milk, eggs), for clothing (fur), and for work (pulling or carrying objects). If necessary, suggest that they classify the animal pictures according to a use you name. At times most of the picture cards may be in one group. The children should recognize that this situation may arise in classification.

Conclude this activity by having the children place all the picture cards on the bulletin board in groupings they determine.

Materials

Animal, 1, live, listed but not used in previous activity
Picture cards, 13, one of each animal: hen, butterfly, dog, kitten, rabbit, hamster, parakeet, bee, grasshopper, duckling, turtle, goldfish, and horse (*Module 14*)

Activity 2

Show the children picture cards of an adult animal and of its young—for example, a hen and a chick, or a cat and a kitten. (Observing a live animal and its young would be a valuable experience for the children if you can arrange this.) Ask the children where these pictures belong among the groupings on the bulletin board. If the earlier grouping was made according to size, these two pictures will probably be in different groups. If it was made according to other characteristics, they may be together. How they are classified is not important so long as the children know the reasons for the classification.

Display the following individual picture cards before the children: hen, chick, turkey hen, turkey chick, lioness, lion cub, doe, and fawn. Have the children describe and discuss each of the pictures. Ask them to suggest a way to arrange the pictures in two main groups. Try out each of their suggestions as they make them, and continue to ask for others until someone suggests putting the young in one group and the adults, or mothers, in another.

Add the pictures to the groups on the bulletin board according to any suitable suggestion. If the children enjoy classifying the animal pictures and need an additional challenge, ask them to group the animals in three groups; then later in four groups.

Materials

Picture cards, 13, of animals, shown in previous activity (*Module 14*)
Picture cards, 8, one of each animal: chick, turkey hen, turkey chick, lioness, lion cub, doe, fawn (*Module 14*), and cat (*Module 13*)

INSTRUCTIONAL PROCEDURE

Alternate Topic: Familiar Things

Introduction

Before introducing familiar objects, ask the children if they remember how they sorted leaves (or nuts, or seashells) earlier in the year. Ask them if they could classify their shoes if all of the shoes were put together in the middle of a circle. (Do this either with everybody's shoes or with a large selection of them.) Ask them in how many ways the shoes could be classified. Color will be an obvious classification. Others might be those with laces and those without laces, or those for the left foot and those for the right foot. Ask if they can classify them by the way they are used. (There may be some special categories in the group, such as tennis shoes and hard-toe shoes, but probably the children will agree that all of the shoes protect their feet and fit one general classification as far as use is concerned.)

Materials

Shoes, an assortment with and without laces and of different colors

Activity 3

On a table, display a collection of objects such as those found in the *Materials* list. Ask a few children in turn to make up sets according to your instructions. For example, you might make such statements as: Bring me a set of red objects. Bring me a set of balloons. Bring me a set of objects I could write with. Bring me a set of wooden ellipses.

After several children have made these sets, tell them to make-believe that they want to send some of these objects to another country, but that country will accept only objects which will fit into this paper bag. (Show them a small bag.) Give each child one or two of the objects. Then have them come to the table a few at a time to decide whether or not the object they have can fit in the bag. If it does, it can be put in the pile "To be sent." If it does not, it goes in the pile "Not to be sent." Point out that they are making a classification according to size (whether or not the object will fit in the paper bag).

If interest continues, repeat this with a larger paper bag.

Materials

Bags, 2, paper, 1 large and 1 small
Balloons, 3, 1 each of the colors red, blue, yellow (*Module 14*)
Ball, 1, rubber (*Module 9*)
Cubes, 3, 1 each of red, blue, and yellow (*Module 3*)
Brick, 1
Can, 1, metal
Chalk, 1 piece
Cookie, 1
Crayons, 12, 4 each of the colors red, blue, and yellow
Candy bar, 1
Hammer, 1
Nails, 2 (*Module 8*)
Pencil, 1
Shapes, 15, felt, of different sizes and colors, three of each shape: square, rectangle, triangle, circle, and ellipse (*Module 2*)
Shapes, 20, wooden, 4 each of large circles, small circles, rectangles, and ellipses (*Module 2*)

Activity 4

Place the items that the children used in *Activity 3* on the floor again in the center of the kindergarten circle. Tell the children that you would like to have them arrange the objects in other ways. Invite individual children to suggest ways in which this could be done. When several suggestions have been made, let the children choose a classification and then have each child choose an object (or two) and place it in the group to which it belongs. One plan that the group will probably suggest is color. If this is chosen, the objects may be divided into four sets, such as blue, red, yellow, and some other color. If the class chooses to use more than four sets, that is fine. As each child places his item, ask him to say why he places it where he does.

If interest continues and time permits, try several different classification schemes that the children may suggest. If your class is ready for it, encourage them to suggest a classification scheme that depends upon use of the objects. The children may suggest that the objects can be used, or not used, for playing, building, writing, and eating.

Materials

Objects, from *Activity 3*

Generalizing Experience

Choose one of the following two options.

1. Display the picture cards of the family, female, and young of several kinds of animals with which they are familiar. You might display the rooster, hen, and chick; lion, lioness and cub; and bull, cow, and calf. Arrange the pictures in front of the children.

Ask the children whether they see any two pictures which may belong together. Ask such questions as: Do you see three pictures which may belong together? (Accept any answer which they can explain reasonably.) Do any of these pictures belong with others already up on the bulletin board? Have the children post or hold the pictures in place as they explain their suggestions.

(Use as many or as few animal pictures as you wish for this review. If practical, you could also put animals in cages or bottles around the room.)

2. You may wish to ask the children to classify a different set of pictures. It is suggested that these be of objects such as a child, a train, a tree, a house, a piece of fruit, a hammer, a book, and a toy. Ask the children to classify these in two ways. Continue to reinforce the idea of a purpose for classification by pointing it out as opportunities arise in the normal activities.

Materials

Picture cards, 27, three for each animal family (*Module 14*)
(Note: Reserve for the *Competency Measure* the three cards for the frog family.)
Pictures, 7, one of each: child, train, tree, house, piece of fruit, hammer, book, and toy
Picture cards, 10, of animals (*Module 14*)
(Note: These should already be on the bulletin board.)

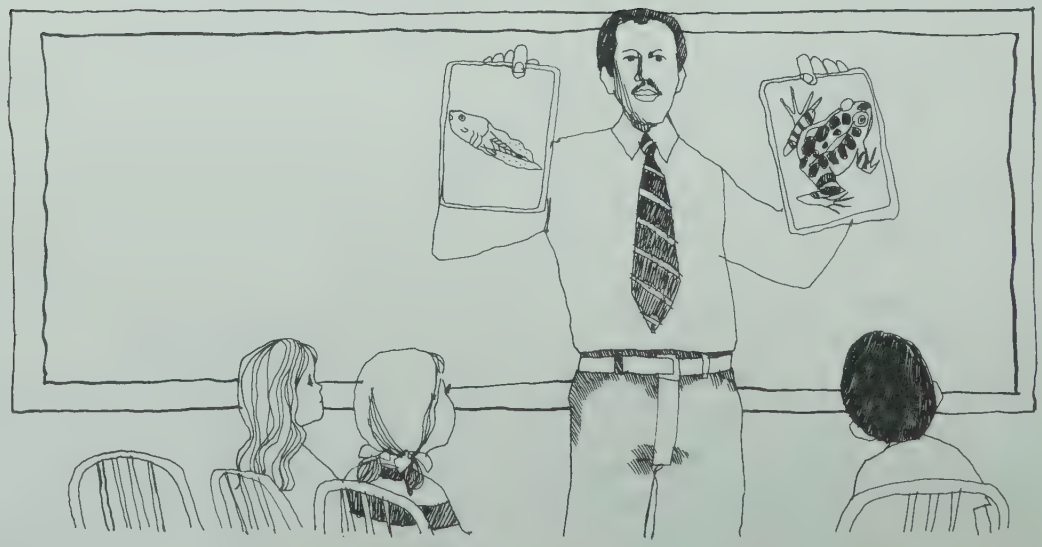

FIGURE 2

APPRAISAL

1. Show the children picture cards of a tadpole and a frog. (See Figure 2.) Ask them to describe what they see. Let them discuss and ask questions about each of the animals. After they have discussed the pictures, ask how they might group them with the pictures on the bulletin board. Pay particular attention to the children who have not yet demonstrated their ability to observe characteristics which provide a basis for classification of the animals. These children may need more individual help in classifying animal picture cards.

2. Show the children the food items listed in the *Materials* list. Have the children classify these as to whether the items come from (1) animals, (2) plants, or (3) neither.

Then suggest that the children classify the same items as to whether (1) the item has a peeling or shell around it, or (2) the item has no peeling or shell covering it.

Materials

Picture cards, 3, tadpole, frog, and tadpole and frog (*Module 14*)
Picture cards, 37, of animals (*Module 14*)
(Note: These should already be on the bulletin board.)
Banana, 1
Egg, 1
Bread, 1 slice
Grape, 1
Nuts, 16, 4 each of 4 different kinds
Orange, 1

COMPETENCY MEASURE

Put the following objects in front of the child: a ball, a cube, bread (one slice), one grape, an orange, an empty metal can, a small plastic container, and a spoon. (Other edible objects may be substituted for the bread, grape, and orange.)

TASK 1 (Objective 1): Tell the child, **Arrange the objects into two groups: one having objects that can be eaten, and the other having those objects that cannot be eaten.** The child should put the bread, grape, and orange into one group and the remaining objects into the other.

Rearrange the objects so that they are all in one group.

TASK 2 (Objective 2): Say to the child, **Put the objects into two or more different groups using some other way of separating them.** The child should arrange the objects into two or more different groups for an acceptable answer.

TASK 3 (Objective 2): Point to one of the groups the child has made and ask, **In what way are all of these objects alike?** When the child has given a reasonable answer, point to another group and ask the same question. If the child gives a reasonable description of the characteristics he has used in his classification, then he will have completed this task successfully.

Materials

Ball, 1, rubber (*Module 9*)
Cube, 1 (*Module 3*)
Bread, 1 slice
Grape, 1
Orange, 1
Can, 1, metal
Container, 1, plastic, small (A vial from *Module 15* might be used.)
Spoon, 1

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14 Classifying/b

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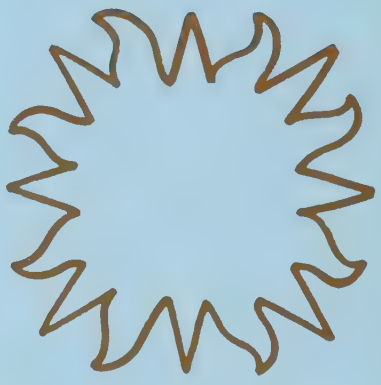

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SCIENCE... A PROCESS APPROACH II

MODULE

15

Observing/f

Perception of Odors

OBJECTIVES

At the end of this module the child should be able to

1. *DISTINGUISH* between objects that have an odor and those that do not.
2. *IDENTIFY* familiar substances by odor.
3. *IDENTIFY* odors of objects as being similar to or different from odors of other objects.

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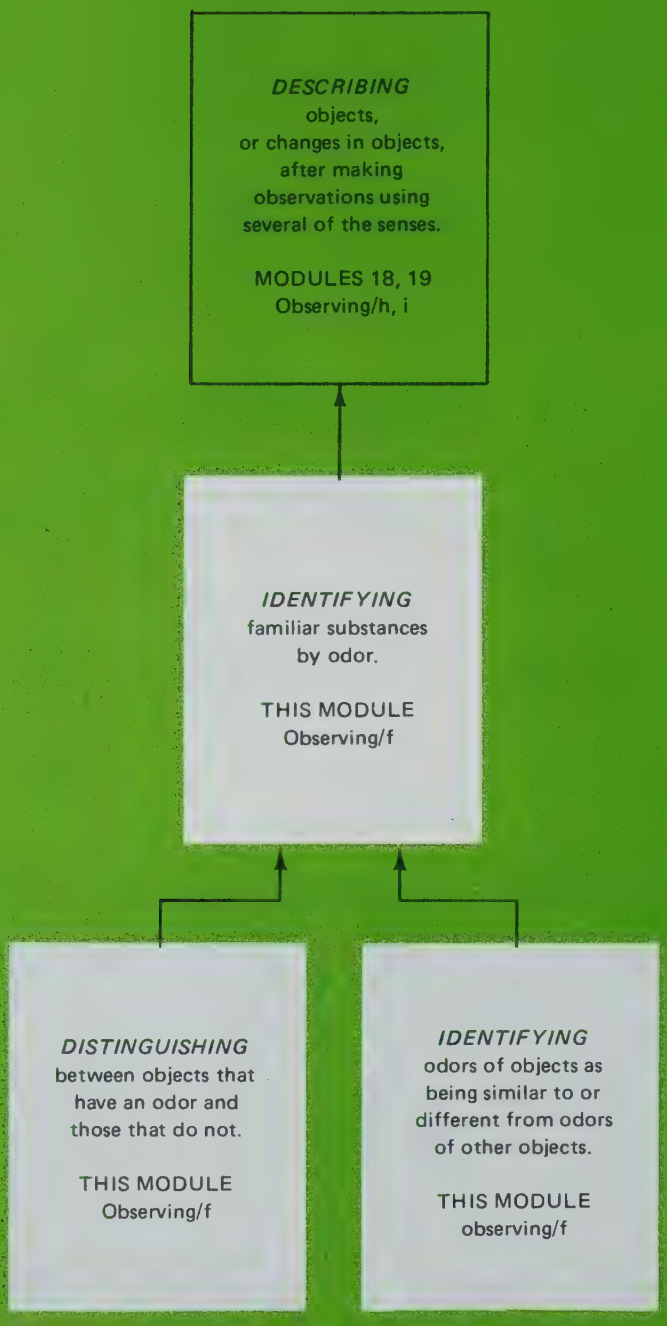

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RATIONALE

The sense of smell is not as sensitive in man as it is in many animals. The dog, for example, depends on the sense of smell as much as on the sense of sight to observe his surroundings. Some male insects depend on their sense of smell to find female insects.

Perhaps it is because our other senses give us more and better information about objects in our environment that the sense of smell is not used very much for making observations. Some individuals—organic chemists and perfume manufacturers, for example—have developed their sense of smell so they can distinguish among many odors that smell alike to the untrained person.

In this module the children will compare and contrast odors of substances found in most kitchens. The children will probably recognize many of them and will be able to name the object that has a particular odor.

There are many descriptive terms for types of odors, but there is no established classification system. We may classify odors as sweet, flowery, spicy, burned, penetrating, and so on, but many objects have mixed types. Cinnamon might be classified as both spicy and sweet. Because it is difficult to classify odors into broad categories, it is more useful to describe odors as like, or most like, some other odor. The children will practice making such comparisons in this module.

Vocabulary

odor perfume
odorless

INSTRUCTIONAL PROCEDURE

Introduction

Put a ball of absorbent cotton in one half of a petri dish and put the dish three or four meters from where the children are sitting. Without letting the children know what it is, put a few drops of perfume on the cotton. Ask the children whether they can guess what you dropped on the cotton. While they are guessing, the children closest to the petri dish will probably smell the perfume and identify it and later those farther away from it will smell it. Ask how they decided it was perfume you put on the cotton. (They smelled it.) Ask how they knew it wasn't water you put on the cotton. (Water doesn't have an odor.) Ask whether there are other things that smell like perfume. (Some flowers, some candies, and some fruit drinks smell like perfume.)

Materials

Petri dish, 1 (*Module 15*)
Cotton balls, 1 box (*Module 15*)
Perfume, 1 small bottle

Activity 1

Give each child a small piece of colored cloth. Use two different colors so that half the class has one color and the other half has the other color. Then ask them to describe the cloth in as many ways as they can think of—as to shape, size, color, texture, and so forth.

Now give each child another piece of cloth of the same size, shape, and texture as before, but of the other color. Have these pieces of cloth differ from the first pieces only in that they contain perfume, so that they have a pronounced odor. When all of the children have the second piece of cloth, ask them again to describe the pieces of cloth. They will probably say, "The blue one has perfume on it." or "The red one smells nice." Through the discussion which follows, try to stress the idea that these pieces of cloth look different and are different in odor since one piece has an odor and the other does not.

Materials

Cloth, 2 pieces each of a different color, to be cut into pieces 5 x 5 cm, (*Module 15*)
Perfume, 1 small bottle

Activity 2

Use three identical paper bags. Put an orange cut into pieces in one paper bag, a spoonful of peanut butter in a second, and squares of plain chocolate bars in the third (perhaps enough for the class to eat afterwards.) Let each child take a turn smelling each bag and have them try to identify the contents. Open the bag just enough so that the children can smell the contents without seeing what is inside. (See Figure 1.)

Materials

Bags, 3, paper, all of the same size
Orange, 1
Peanut butter
Chocolate bars, plain, enough for each child to have a square

FIGURE 1

Activity 3

Put the following items, each in a 30-milliliter clear plastic vial, on a table where the children can investigate them individually or in small groups. Use about 10 milliliters of each liquid and 2 or 3 grams of each solid.

vanilla extract	piece of banana (or banana flavoring)
liquid detergent (perfumed)	cloves
orange juice	cinnamon
cedar furniture oil	nutmeg
pine oil cleaner	fruit drink powder

A ball of cotton in each liquid will help keep it from being spilled. (See Figure 2.)

Tell the children that the vials are for them to smell and suggest that they might group together those that smell the most alike. Caution them to smell only—*not* taste. After each child or small group of children has grouped the vials by odor, ask him to tell you why he grouped them as he did. Accept all groupings the children suggest and do not expect them to use descriptive terms such as spicy or fruity in comparing odors. Also keep in mind that individuals vary in their ability to detect odors. Some people are "odor blind" to certain odors.

Materials

Vials, 10, with caps, clear plastic, 30-ml (*Module 15*)
Vanilla extract, 10 ml
Liquid detergent (perfumed), 10 ml
Orange juice, 10 ml
Cedar furniture oil, 10 ml
Pine oil cleaner, 10 ml
Banana, 2-3 grams, or banana flavoring
Cloves, 2-3 grams
Cinnamon, 2-3 grams
Nutmeg, 2-3 grams
Fruit drink powder, 2-3 grams
Cotton balls, 1 box (*Module 15*)

FIGURE 2

Activity 4 (Optional)

Ask the children to bring from home something that has a fragrance they want to share with the other children. It could be their favorite soap, a slice of bread, a cookie, a banana, or shoe polish, for example. Have the children bring their items in brown paper bags with the tops tied loosely as shown in Figure 3, so one can smell but not see what is in the bag. The bags might be placed on a table where the children could examine them in small groups, or they could be passed around a circle. As the children smell each bag, ask them if they can tell what is in it. You might ask the children to try putting the bags into groupings according to similar odors. After all the children have had an opportunity to smell each bag, open them and let the children see what is inside.

Materials

Items having distinct odors, brought in paper bags by children

Generalizing Experience

The children may be interested in discovering that there is a connection between the sense of taste and the sense of smell. Some of them may already know this if they have had a cold and noticed that food has a different taste when they cannot breathe through their noses.

Under your supervision they might try tasting various substances as they pinch their own noses closed between thumb and forefinger. Some substances have a different flavor but others do not. Chocolate has little flavor when the nose is closed, but the taste of salt is not much different.

FIGURE 3

APPRAISAL

Give small groups of children five pieces of paper towel, each piece moistened with a drop of a different liquid. The following liquids should be used:

wintergreen oil	eucalyptus oil
peppermint oil	camphor oil
turpentine	

Also give each group two pieces of paper towel moistened with a drop of water. Ask the children to group the pieces of paper into two groups: one that has odors and the other that does not. Then ask them whether they have smelled any of these odors before. Most should recognize wintergreen and peppermint, and many will probably be able to name the latter one.

Ask the children to group the pieces of paper towel into those that smell most like each other. A likely arrangement might be:

wintergreen	turpentine	eucalyptus	odorless
peppermint		camphor	

Accept any other arrangements that the children may suggest.

Materials

Paper towels
Wintergreen oil, 5 ml
Peppermint oil, 5 ml
Turpentine, 5 ml
Eucalyptus oil, 5 ml
Camphor oil, 5 ml

COMPETENCY MEASURE

Do not test a child if he has a cold.

TASK 1 (Objective 1): Give the child two clear plastic 30-milliliter vials, one containing a little water and the other a little white vinegar. Say, Smell these and tell me if these are the same or different. The child should say that the vial containing vinegar has an odor and the vial containing water is odorless.

TASK 2 (Objective 2): Put a piece of onion in a paper bag. Do not let the child see the onion. Say, Smell this but do not look into the bag. Tell me what it smells like. The child should say it smells like an onion, or some food that has onion in it.

TASK 3 (Objective 3): Give the child a freshly cut piece of apple and put in front of him freshly cut pieces of potato and fresh pear. Say, Smell each of these and tell me which of these (point to the pear and the potato)smells most like the apple. The child should identify the pear as smelling most like the apple.

Materials

Vials, 2, clear plastic, 30-ml (*Module 15*)
Vinegar, 5 ml, white (*Module 6*)
Onion, 1 piece
Bag, 1, paper
Apple, 1 piece
Potato, several pieces
Pear, several pieces

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15 Observing/f

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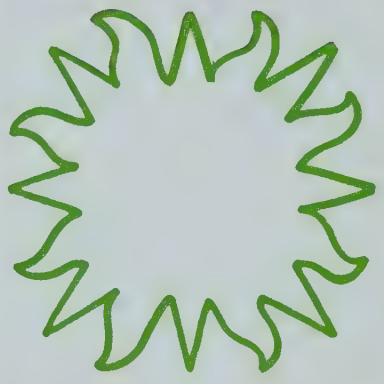

A PROCESS APPROACH II

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SCIENCE... A PROCESS APPROACH II

MODULE

16

Classifying/c

ALTERNATE TOPICS:

Living and Nonliving Things
Trees in Our Environment

OBJECTIVES

At the end of this module the child should be able to

1. *NAME* at least one characteristic of living things.
2. *CONSTRUCT* groupings of living and nonliving things on the basis of observable characteristics.

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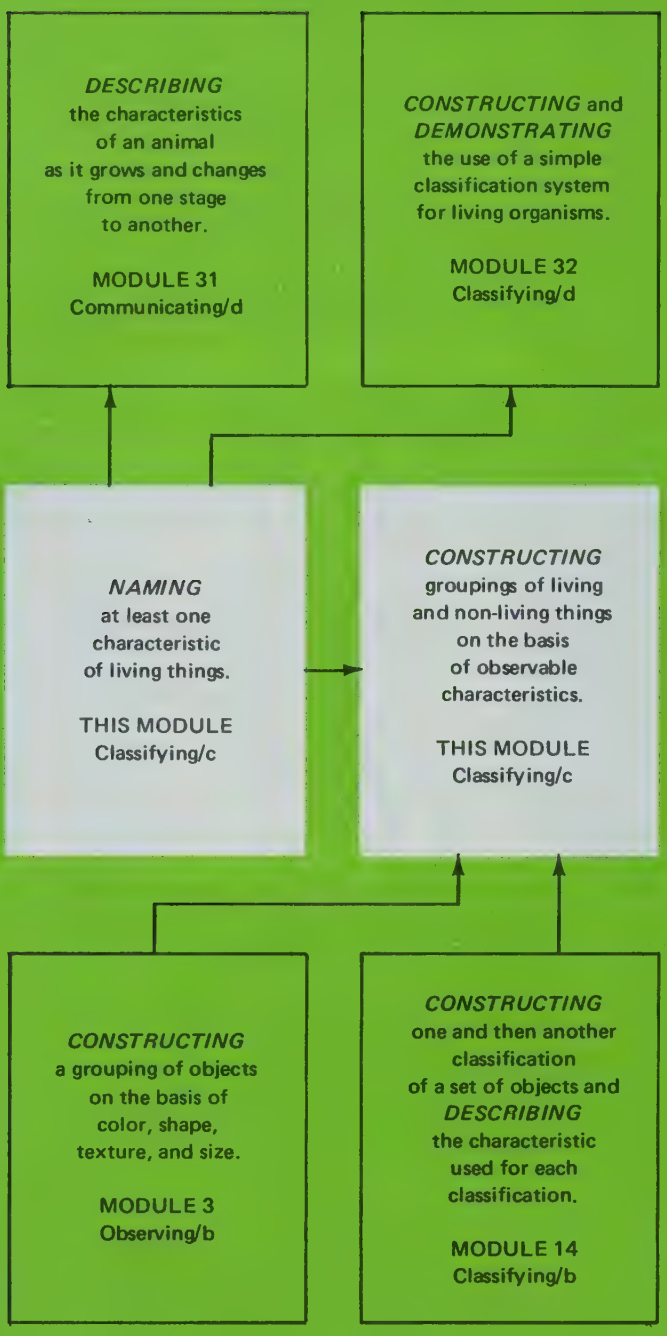

Use of this chart, the instruction booklet, and other elements of **Science. . .A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

Children have a deep interest in living things. They enjoy playing with them, discussing them, and caring for them. Their observations of living things, however, are often made too quickly and superficially.

This module is designed to give the children more experience in observing living and nonliving things and in noting the differences between them. After making these observations, the children should be able to suggest characteristics of living and nonliving things and to use this knowledge in grouping living things together and nonliving things together. The characteristics that the children suggest may not be those that adults would suggest. Nevertheless, the characteristics will provide a basis for further observations and discussion throughout the year.

This module provides a choice between two alternate topics. *Living and Nonliving Things* focuses on making and observing an aquarium; *Trees in Our Environment* provides opportunities for the observation of trees in the children's environment. It is recommended that the children study only one of the two topics and that the selection be based on the availability of aquarium supplies on the one hand, and on the accessibility to trees on the other hand. If both studies are feasible, you may wish to allow some children to study the aquarium and others, the trees. The tree and aquarium activities are open-ended and need not be considered complete even at the end of the school year.

In the first topic, the children distinguish between the living and nonliving things in an aquarium. As they maintain and observe the aquarium, the children learn about some characteristics of living things: their need for such things as food and air, their growth and reproduction. The living things that can be kept successfully in a school aquarium are good subjects for study. Some characteristics of the organisms can be observed easily, and the observations may be continued over a period of time. A book on the management of an aquarium will be useful. You should be able to find one in your library or pet store.

In the second topic, each child selects a tree, which is located in some place where it can be frequently seen, and finds out as much about it as possible. The child learns to distinguish between the selected tree and other trees, and to describe the tree in enough detail to enable other children to identify it. It is recommended that the study be initiated in the fall and continued throughout the year, particularly in a climate in which there is a noticeable seasonal change in the trees, so that the children develop a habit of observing and classifying trees. A one-stage classification is suggested based on the difference between broad-leafed trees and conifers. The children also learn to distinguish between living and nonliving trees.

A Tree Diary, Communicating f, Module 47 provides an additional activity in classifying trees. If you think some of the children are ready for this individualized module, give them an opportunity to use it.

Vocabulary

aquarium	bark
fish	stem
snails	blossoms
water plants	fruit
alive	artificial
not alive	cross section
living	broad-leafed
nonliving	conifer
fins	fir
trunk	spruce

Advance Preparation

You will need to draw the water for the aquarium the day before you fill it. (See *Activity 1.*)

INSTRUCTIONAL PROCEDURE

Alternate Topic: Living and Nonliving Things

Introduction

Show the children a toy snail and ask what it is. Then show them a living snail and ask what that is. They will probably answer "snail" to each question. Now ask the children to look at the two snails more closely. Put them both on a table side by side, and ask the children to talk about how the snails are different. Someone may say that one of the two snails is "alive" or "real." Or, some children may express the idea that the living snail moves by itself rather than by being pushed. Ask whether the snails are different in any other ways. The children may suggest that the snails differ in size, that the living snail needs food and air, and that the living snail may grow. Accept the children's suggestions without trying to expand or evaluate them.

Materials

Snail, 1, toy (*Module 16*)
Snail, 1, live

Activity 1

Show the children the following items: water plants, small fish, snails, sand, and a few ornamental objects, such as shells, marbles, and coral. (See Figure 1.) Substitutions can be made from the local environment. (See *Materials* for suggested varieties of fish.) The water plants, the fish, and the snails should each be in separate covered containers with aquarium water and air.

As you hold each container up, ask the children to tell what they know about the item inside. When they have identified all of the items, show them the two snails used in the previous activity. This time, put the snails at opposite sides of a table. Ask the children to help you sort the collection of items into two groups, each group including one snail. Make any grouping that the children suggest. As you hold up each item and the children suggest a way to group it, ask why they made that particular suggestion. After each item has been placed in one of the two groups, have the children name each group. The children may immediately suggest "alive" and "not alive." If not, continue with other groupings until the children do make this classification and suggest suitable names for the two groups.

Ask the children how they might keep the items in the room. Show them the aquarium. They will probably agree that it will do nicely. Assign tasks and responsibilities to the children to help you set up the aquarium. You might assign different groups of children to be responsible for the sand, water, plants, animals, and nonliving things. You may find the following procedures useful.

1. With the help of some children, wash the sand and put it in the aquarium. (Note: If you wash the sand in the sink, put a cotton cloth or sheet in the sink to keep sand particles from washing down the drain.)

2. Water for the aquarium should be drawn one day before living things are added to the aquarium. Set aside enough water to fill the aquarium. You might have a second container of water set aside in case of spills.

3. When you are ready to set up the aquarium, mark the glass tank to indicate the level at which the tank is half full. Have the children come to the aquarium, a few at a time, and add water container by container, until the aquarium is half full. Assign one child to monitor the water level and to keep a count of the number of containers of

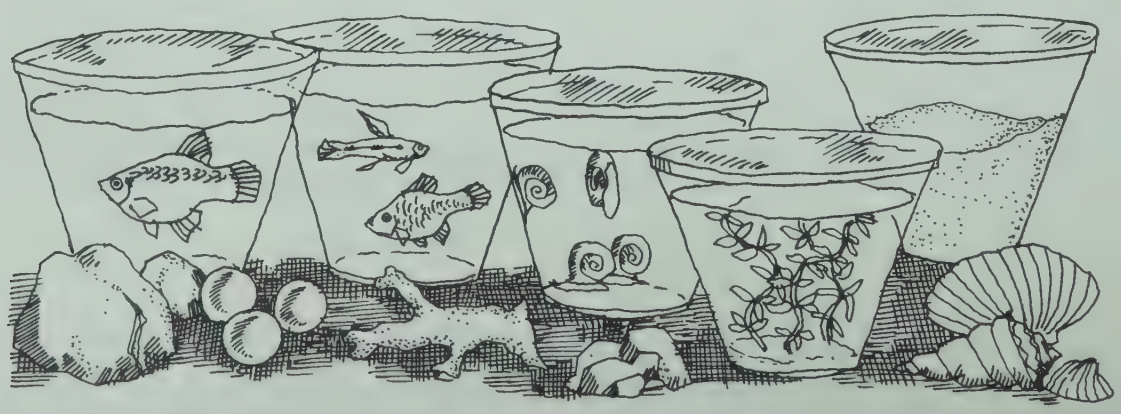

FIGURE 1

water used to fill the aquarium half way. Have the children estimate how many containers it will take to fill the entire aquarium. (See Figure 2.)

4. Next add the plants. Let the children responsible for the plants decide upon their arrangement and place them accordingly.

5. The children who are in charge of working with the nonliving things can next place the ornamental objects.

6. Live, shelled animals, such as the snails, can also be placed in the aquarium at this time, but should be removed immediately if they die, or they will quickly foul the water.

7. Now add additional water to fill the tank to within 5 centimeters of the top. Check the number of containers used, against the number of containers estimated to fill the aquarium.

8. If you wish, attach a heater and a filter to the aquarium. For tropical fish, this equipment is highly recommended. A filter keeps the tank relatively clean. A heater keeps the water at an optimum temperature during the week and especially through the weekends when the classroom's heat may be considerably reduced. Optimum temperatures are as follows: for guppies, 24° to 28°C; for platies, 20° to 26°C; for zebra fish, 18° to 28°C. Goldfish are extremely hardy, do not require a heater, and usually do well from 16° to 22°C.

9. Next let the children put the animals into the tank. The aquarium will then be complete.

Materials

Fish, 6-10 guppies, platies, or zebra fish; male and female
(Note: Select zebra fish, guppies, or platies because these are quite hardy tropical fish. The zebra fish is not a live-bearer and usually will not reproduce in an ordinary tank. The guppies and platies are live-bearers. If the aquarium does *not* have a filter and/or aerator, use at least 4 liters of water for every 2.5 cm of fish – length excluding the tail. The average length of the suggested kinds of fish is 4 cm.)
Plants, 5-8 branches, such as elodea
Snails, 4-8, common aquarium
Sand, coarse, enough to make a layer 5 cm deep in aquarium (*Module 16*)
Shells, 3, assorted (*Module 16*)
Marbles, 3, or other ornamental objects
Coral, 1 piece (*Module 16*)
Containers, 4, 1-liter, clear plastic, with covers (*Module 16*)
Snail, 1, toy (*Module 16*)
Cotton cloth, 1, large enough to cover bottom of sink
Containers or pails, 2, for storing aquarium water
Aquarium, 1, 16-liter
(Note: If a 16-liter aquarium is unavailable, a large jar may be substituted.)
Containers, 4, 250-ml, clear plastic, for filling aquarium (*Module 28*)
Filter, 1 (optional)
Heater, 1 (optional)
Fish food
Thermometer, 1, Celsius (optional) (*Module 21*)

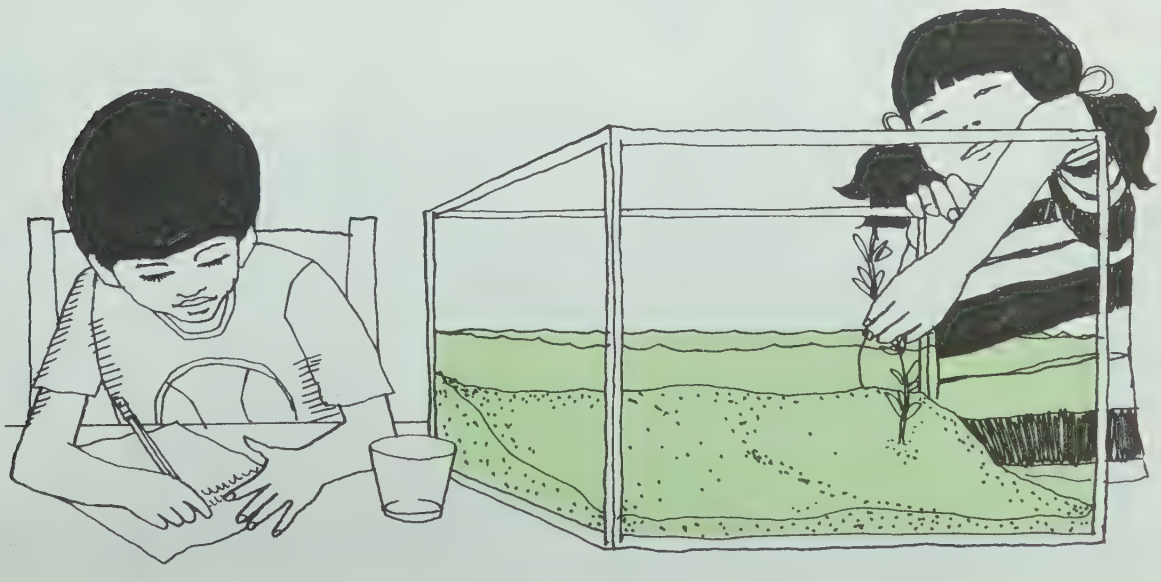

FIGURE 2

Activity 2

Encourage the children to observe the fish in the aquarium. (See Figure 3.) Ask the class to describe what the fish are doing. If the children do not know the word "fin," point out the fins.

The guppies and platies are quite likely to reproduce, and so are the snails. Guppies and platies are live-bearing fish. Snails lay eggs from time to time during the year. Encourage the children to count the snails and fish frequently. Do they notice an increase? Ask whether any of the nonliving things have increased in number. If some of the children observe guppies being born, help them to verbalize what they have seen. Also ask if there have been any changes among the plants. The children may notice that the plants are growing in length, getting more leaves, dying, or being eaten.

If the children can state in their own words that living things grow, need food and air, and reproduce, they will have learned many characteristics of living things. Even if some children recognize only one of these characteristics, consider this as acceptable.

Some ecological concepts can be introduced by having the children discuss some questions, such as those listed below. Pursue these in the simplest terms, and do not require specific answers.

Why might we need a filter for our aquarium?
Why do we call snails "nature's garbage collectors"?
Do living things die? If so, what happens to their remains?
Do plants need animals?
Do animals need plants?

Materials

Aquarium, 1, as set up in *Activity 1*

Activity 3

Take the children on a trip around the school grounds, and ask them to look for living things along the way. Ask what is meant by "living." If they say, "Something that moves by itself," ask if cars and airplanes are alive. These can certainly move by themselves under certain conditions. But are they living? If the children say, "Something that can grow and make more like itself," ask them if grass, trees, bushes, flowers, birds, dogs, and ants can do this. When you return to the classroom, list the names of some of the things seen on the trip that are living and some that are not. Follow this with a discussion about what the children observed that led them to the grouping suggestion.

A collection of pictures illustrating some of the things in each group would be helpful. The children might like to make collages by assembling pictures of living and nonliving things cut from magazines.

Materials

Pictures, collection, illustrating living and nonliving things

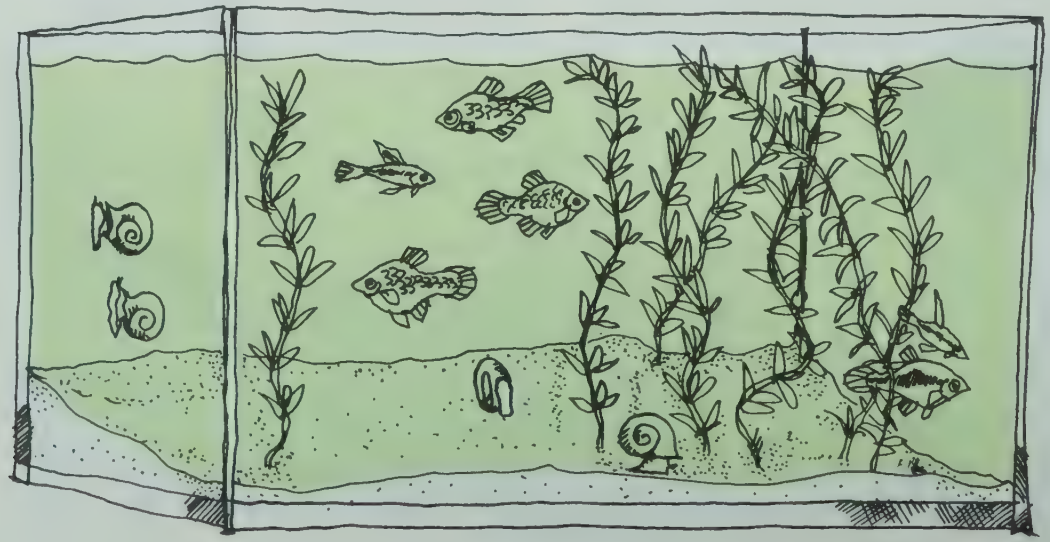

FIGURE 3

INSTRUCTIONAL PROCEDURE

Alternate Topic: Trees in Our Environment

Introduction

On a walk with the children, call attention to trees along the way. Encourage the class to talk, to ask questions, and to make observations about the trees they see. If you have the children take paper and crayons on the walk, they can, from time to time, sit down and draw pictures of trees that they see. When the children return to the classroom, continue discussing the trees that were seen. Ask each child to draw a picture of one of the trees from memory. Display as many of the drawings as possible on the bulletin board.

Supplement the children's drawings with pictures or slides of trees. Show the picture card of the giant redwood tree and, for contrast, the picture card of the bonsai tree. Encourage discussion and questions.

Ask each child to select a tree for special study. The tree should be one that the child can see and study often. It might be located in the yard at home, somewhere on the way to school, or in the school yard.

Materials

Drawing paper, 1 sheet for each child
Crayons, 1 box for each child
Picture cards, 2, bonsai tree and redwood tree (*Module 16*)

Activity 1

Using questions such as those that follow, ask some of the children to tell about the trees that they have chosen.

Where is the tree?
Is it tall?
Does it have flowers?
Does it have fruit?
Have you seen any of its seeds?
Are there bird's nests in its branches?
What color are its leaves?
How many leaves does it have?
Is its bark smooth or rough?
Does it provide lots of shade?
What kind of tree is it?

After the children have talked about trees, have them help you make a list of questions that each child should try to answer in reference to the characteristics of his or her tree. Only include in the list questions that the children identify. At some point during the discussion, you may want to have the children tell where their trees are so that you will know that everyone has selected a tree. You may wish to consult reference material to help the child determine what kind of tree he or she has chosen.

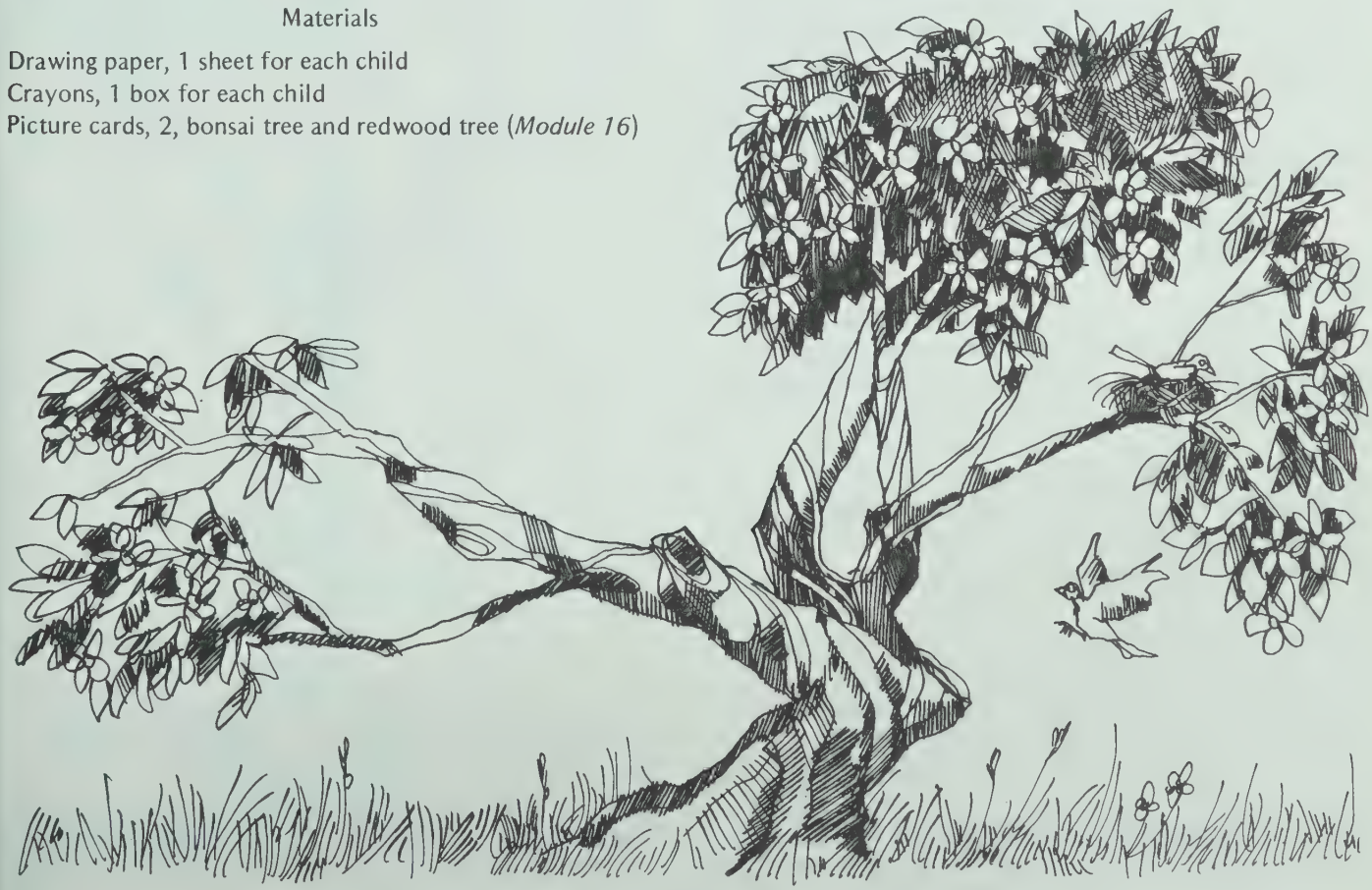

FIGURE 4

Activity 2

In this activity the children should begin developing the ability to identify the characteristics of living trees and contrast these characteristics with those of nonliving trees. One way to introduce the distinction between living and nonliving things is to ask if any of the children have seen a dead tree. Perhaps nearby there is a dead tree that the children can visit.

Ask the children to tell how they know that a tree is dead. The children may explain by making statements such as:

A dead tree has no leaves.
Its branches and trunk look bare and gray.
Its branches are easy to break.
You can see broken branches.
The tree looks rough and dry.

Suggest that the children find "dead" sticks that have fallen on the ground. Classroom examination of these sticks should suggest to the children other characteristics of "dead" trees. For the purpose of comparison, have in the classroom a few small branches or twigs that have recently been removed from live trees. *CAUTION: Twigs or branches should not be cut or broken from live trees unless permission has been given by the owner of the property where the trees are growing.*

During a discussion of living and nonliving trees, encourage the children's interest in the use of wood products obtained from trees. Ask what items in the classroom are made of trees. Were living or nonliving trees used to make these products? Why? Is the wood in them now living?

If autumn leaves fall from deciduous trees in your climate, discuss the idea that the trees are resting rather than dying.

At Christmas time you might have the children compare artificial trees, Christmas trees with balled roots, and cut Christmas trees. Ask what can happen to each kind of tree after the Christmas season.

Materials

Twigs and branches, variety of kinds, recently removed from live trees

Activity 3

This activity, a continuation of *Activity 1*, gives children opportunity to make more detailed observations of their trees. If this activity is extended throughout the school year, children can observe seasonal changes.

By listing questions as in *Activity 1*, you can help the children make more complete observations of their trees. Do not tell them what they are to look for. Rather let their suggestions arise naturally from their own conversations and observations.

As the children observe their trees, encourage them to record their observations. At first, records might be made from pictures cut out of newspapers and magazines, or pictures drawn by the children. As word skills develop, written descriptions might be used.

Help the children make their observations by asking questions such as: How large around is the tree? How tall is it? Does it contain worm or insect or woodpecker holes? Is the tree strong and straight, or crooked? The list that

FIGURE 5

follows suggests additional kinds of observations for which you might develop questions.

bark . . . . color, texture, thickness
leaves . . . color, shape, texture, size, arrangement on twigs
buds . . . . shape, size, parts
flowers . . color, size, shape, parts
fruit . . . . color, shape, size, taste (*CAUTION: Not all fruits are edible.*)

Encourage children to observe and record seasonal changes that occur in trees. These changes may be more noticeable and of greater interest to children in northern climates. From fall through spring, the children should be alerted to the appearance of leaf buds and flower buds, the appearance of flowers (sometimes before the unfolding of the leaves), and the eventual development of leaves and fruit or seeds.

It may be of interest to some children to observe how late in the spring some trees or shrubs show signs of life. These trees or shrubs have more brittle stems than the ones that develop earlier. The crepe myrtle, common to warmer climates, is a good example of a late-developing shrub.

Materials

Drawing paper, several sheets for each child
Crayons, 1 box for each child

Activity 4

The study of trees provides an excellent opportunity for the development of classification skills. In this activity a one-stage classification is proposed—one requiring a distinction between the broad-leafed trees, such as maple, oak, and beech, and the conifers, such as pine, fir, and spruce. Such a classification scheme is often used by foresters and should occur to children in most climates as a useful scheme.

Another way to make the same classification is to distinguish between trees that lose their leaves in autumn and those that do not. (It may be necessary for some children to wait until autumn to understand this classification scheme.) Care must be used in this classification, however. For example, the larch is a conifer that loses its needles in winter. Another exception is the magnolia, a broad-leafed tree, that does not lose its leaves in winter. If this is not an obvious classification in your climate, you may wish to suggest some other one-stage classification.

Have the children design a method or methods for identification of trees that they classify. Quite a number of possibilities exist. The child might identify the tree by its common name, such as oak or maple or apple, by a number placed on a "rough" map of the area, or by some characteristic of the tree. Since children are often more ingenious in naming things than adults, schemes they develop may be much better than any we could suggest.

Activity 5 (Optional)

This activity focuses attention on the children's environment with special reference to trees as a part of that environment. Discuss with the children the components of their environment. The air they breathe, the soil and grass upon which they walk, the trees, the buildings, and the people among which they live are all parts of this environment.

Ask what it is that trees contribute to their environment. All the children should become involved in the discussion. Encourage the children to participate by asking why each child likes his or her tree. Some responses might be:

It is pretty.
It gives shade.
It has fruit.
I like the blossoms that come on it.
It looks strong.
I like to see the wind blowing through it.
I can fasten my swing to it.
I like to watch it from the time the buds start to swell in the spring until the leaves drop in the fall.
I like to climb it.
It is fun to build a tree house and play in it. (If this is suggested you might ask the child to describe the environment surrounding a treehouse.)

The children may want to discuss ways in which trees are helpful to man and ways in which trees may not be so helpful.

Ask the children if they think the living or the nonliving things in their environment contribute more to making the environment pleasant. This may start an argument!

Generalizing Experiences

It is suggested that one of the experiences that follow be selected. None of the experiences requires a background in specific science content. If the children have studied *Trees in Our Environment*, you may want to choose the first experience, a study of small animals in the classroom. However, if the children have studied *Living and Nonliving Things*, you may wish to select the second or third experience to provide them with an opportunity to study trees.

1. Bring one or two tadpoles, gerbils, or common small animals to school. Use the animals as models that illustrate the characteristics of living things and, thereby, help the children to distinguish between living and nonliving things. Select children to prepare suitable places for the animals to live. (See Figure 6.) Assign tasks such as feeding and cleaning up to other children. Explain that the animals may be kept as classroom pets after the module has been completed.

2. Ask the children to tell you where they may have seen a grove or orchard. Plan a class visit to this location. Suggest that the children observe the likenesses and differences among the trees. The children may notice that some trees are tall and some short, that some have large trunks and some have small ones. If there are dead stumps or logs in the grove, wait for the children to notice them before you point them out. If a freshly cut stump should show the rings of seasonal growth of the tree, discuss them with the children and have the children draw the rings. Encourage the children to tell about the differences between the nonliving trees and the living ones. Ask the children to draw a picture of a grove. If the grove that you visit contains trees of different kinds, ask the children to show these differences in their drawings.

3. Have the children make scrapbooks containing drawings and pictures of trees. Sample leaves, flowers, and seeds might be included, as well as samples of cut wood showing the growth rings and the grains of various kinds of wood. Some children may want to add magazine pictures that show how trees are used.

Materials

Small animals, several, such as tadpoles and gerbils
Containers, suitable for animals chosen
Food, suitable for animals chosen
Drawing paper, several sheets for each child
Crayons, 1 box for each child

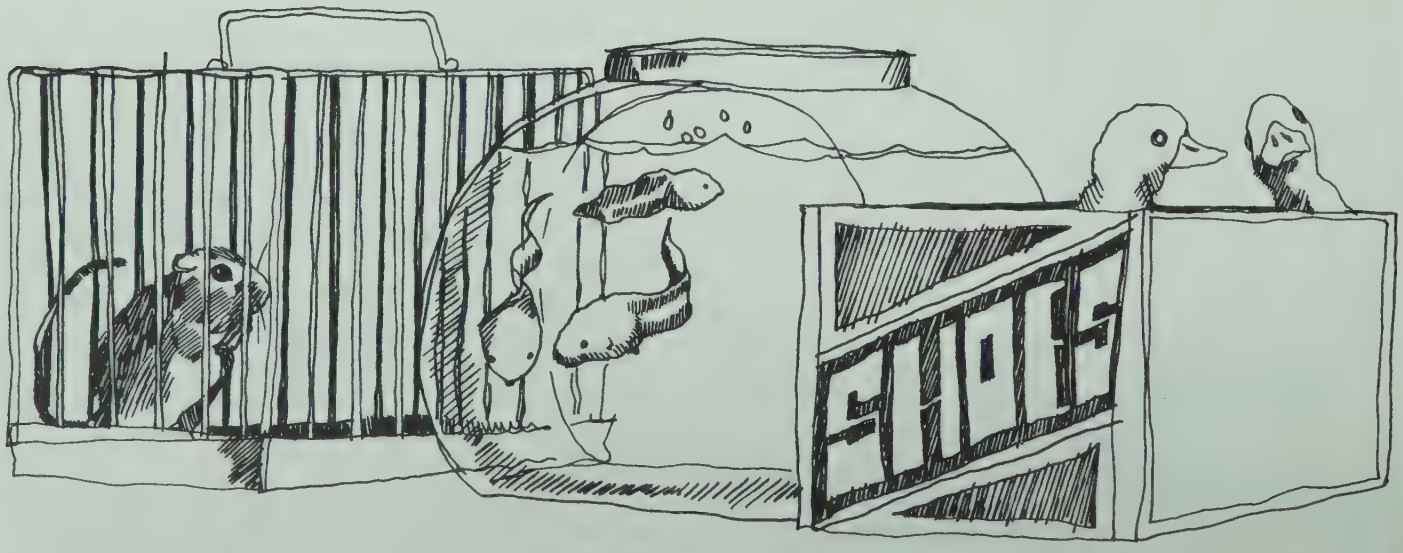

FIGURE 6

APPRAISAL

Call the children's attention to the living plants in the room. In groups of two, have the children observe, discuss, and list the living and the nonliving characteristics of the plants. You might be called upon to resolve arguments. If there are insects on your plants, give the children the choice of naming some living characteristics of the insects or of the plants.

Ask each child to put five things in the room into two sets, one set consisting of living things and the other of nonliving things. Here you may wish to suggest that the child draw pictures to show groupings, or identify the things by name and group the names.

Materials

Potted plants, several
Drawing paper, 1 sheet for each child
Crayons, 1 box for each child

COMPETENCY MEASURE

TASK 1 (Objective 1): Say to the child, Tell me one way that we can know whether something is living. The child should name at least one characteristic of living things by making such statements as: It grows; it reproduces; it needs food and water; or it needs air.

TASK 2 (Objective 2): Arrange a mechanical toy animal, a ruler, a potted plant, a snail (in a small container of water), and a rock in front of the child. Say, Here are some living and nonliving things. Put the living things here. (Point to one place on the table.) Put the nonliving things here. (Point to another part of the table.) The child should group the plant and the snail as living things and the remainder as nonliving things.

Display for the child a number of living plants (or flowers) and a number of artificial ones.

TASK 3 (Objective 1): Say to the child, Here are a number of living plants and artificial plants (flowers). I will want you to tell me which of them are living and which are nonliving, but first tell me how you know whether or not something is living. The child should name one characteristic of living things by making statements such as: It grows; it must have light; it must have food and water; its leaves and stalk are not stiff; it has seeds in it.

TASK 4 (Objective 2): Say to the child, Show me how to group these into two groups. In one group put the living plants; in the other, the nonliving plants. If the living plants or flowers have been only recently cut, say, Count as living those plants that have just been cut from living plants. The child should make no more than one error.

Materials

Toy animal, 1, mechanical (*Module 16*)
Ruler, 1
Living plants, several, potted
Snail, 1
Container, 1, 250-ml, clear plastic (*Module 28*)
Rock, 1
Artificial plants, several, unpotted or potted

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16 Classifying/c

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SCIENCE... A PROCESS APPROACH II

MODULE

17

Observing/g

Change

OBJECTIVES

At the end of this module the child should be able to

1. *IDENTIFY* a substance as a solid or a liquid.
2. *NAME* the initial and final color of a solid or liquid that changes color.
3. *DESCRIBE* changes in color, shape, size, and phase (changes from solid to liquid and liquid to solid).

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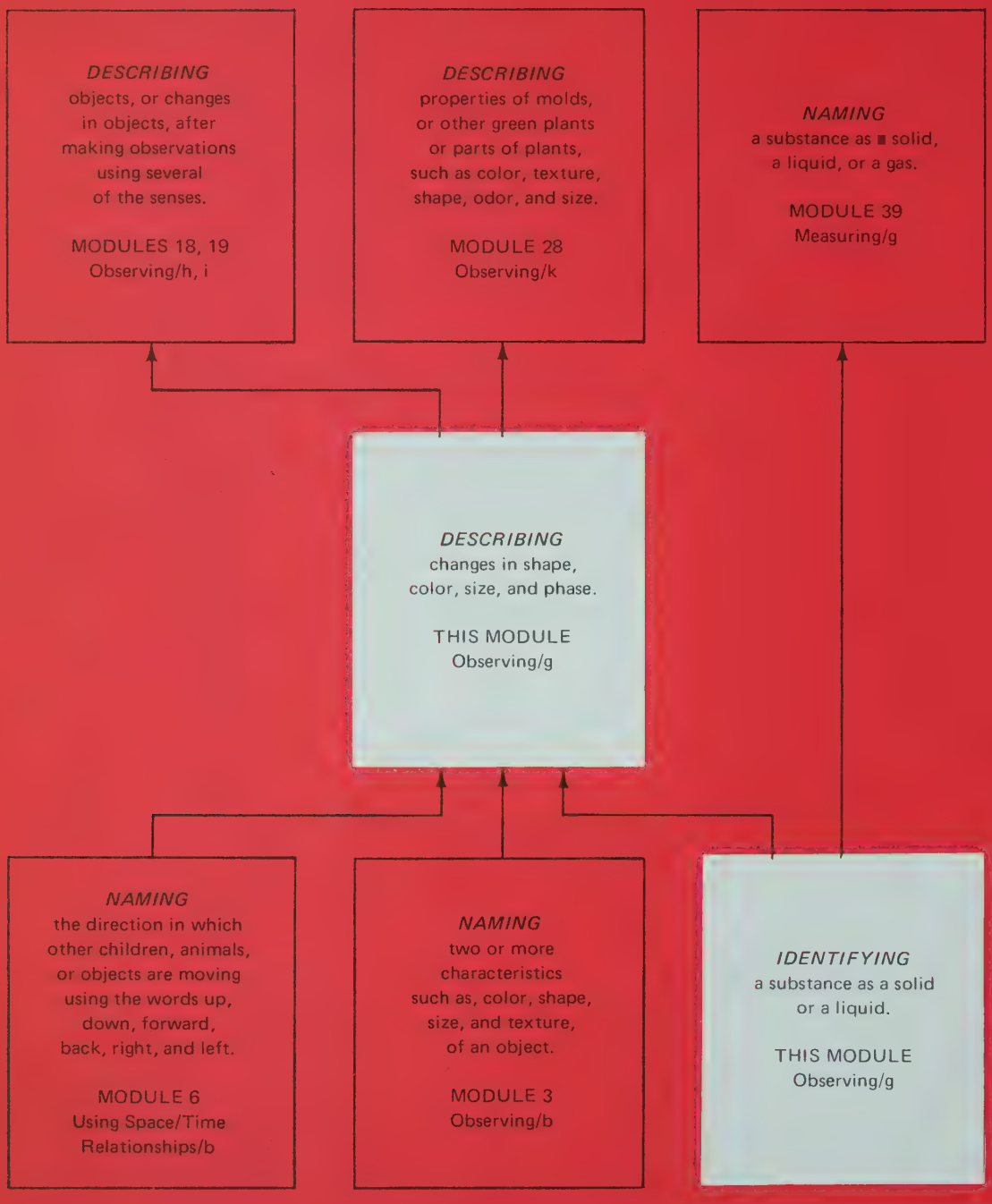
SEQUENCE


DESCRIBING
objects, or changes in objects, after making observations using several of the senses.
MODULES 18, 19
Observing/h, i
DESCRIBING
properties of molds, or other green plants or parts of plants, such as color, texture, shape, odor, and size.
MODULE 28
Observing/k
NAMING
a substance as a solid, a liquid, or a gas.
MODULE 39
Measuring/g
DESCRIBING
changes in shape, color, size, and phase.
THIS MODULE
Observing/g
NAMING
the direction in which other children, animals, or objects are moving using the words up, down, forward, back, right, and left.
MODULE 6
Using Space/Time Relationships/b
NAMING
two or more characteristics such as, color, shape, size, and texture, of an object.
MODULE 3
Observing/b
IDENTIFYING
a substance as a solid or a liquid.
THIS MODULE
Observing/g

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

In their everyday experiences at home and in school, children have many opportunities to observe change. The first emphasis on change in *Science . . . A Process Approach* is in *Direction and Movement, Using Space/Time Relationships b, Module 6*. There the children observed and described change of position. The present module presents the children with many varied opportunities to observe changes in color, shape, size, and phase. The phase changes include the change of solid to liquid and of liquid to solid.

Because the children may have trouble understanding the concepts of *liquid* and *solid*, you should keep the definitions quite simple. For example, a *liquid* is something "runny" like water; a *solid* is something that keeps its shape.

Vocabulary

change	liquid
solid	solution

INSTRUCTIONAL PROCEDURE

Introduction

Put two 120-milliliter, clear containers in a place where all the class can see them. Fill the containers with equal quantities of water. Using drops of food coloring, color the water in one container blue and in the other container yellow. Add the same number of drops of food coloring to each container. One drop per 30 milliliters of water may work very well. The amount of food coloring for larger containers should be determined previously by trial. The colors are the proper concentration when about equal quantities of the blue solution and yellow solution produce a solution that is bright green.

Put six squares of colored paper—yellow, orange, red, purple, blue and green—near the containers. Ask a child to select the square that is closest in color to the solution in one of the containers. Have the child place the square next to that solution. Ask another child to name the color. Repeat this process for the other container.

Ask one of the children to pour about 30 milliliters of yellow solution into a 120-milliliter container and then slowly add about 30 milliliters of blue solution to it. The color of the combined solutions should be green.

Ask another child to select the colored square that is most like the color of the combined solutions, and to put it near that solution. Ask still another child to name the color.

Emphasize the concept of change as you and the children talk about what has happened. The children should be able to name the colors of the solutions before and after they are combined. They should be able to state that the color of the solution changed from yellow to green when the blue solution was added.

An overhead projector can be used to provide an interesting variation of the demonstration. Put containers or petri dishes of the yellow solution and the blue solution side by side on the projection surface of the projector. The solutions in these containers should be less than one centimeter deep. When the light is turned on, the containers will appear on the projection screen as a blue disk and a yellow disk. If one container is lifted and held over the other so that the light must pass through both, green appears on the screen where the yellow and blue disks overlap. The colors can be separated by moving the containers apart so that there is no overlap.

Suggest that the children try to combine food colors at home, and send the parents instructions so that they can help the children prepare the dilute solutions. The children might try combining other colors besides blue and yellow.

Materials

Containers, 2, 30-ml, clear plastic (*Module 17*)
Containers, 3, 120-ml, clear plastic (*Module 17*)
Food coloring, 1 container, yellow (*Module 17*)
Food coloring, 1 container, blue (*Module 17*)
Paper squares, 6, one of each color: red, orange, yellow, green, blue, and purple

Activity 1

Give each child a yellow crayon, a blue crayon, and a sheet of white paper. Ask the class how they think they might be able to make green marks by using these crayons. If they do not suggest combining blue and yellow crayon marks on the paper, remind them that they made a green solution by combining yellow and blue solutions. Then ask the children to try to make green by using the crayons. They might draw blue lines and color over them with yellow, or vice versa. They will have the most success if they make yellow marks crosswise over the blue marks and if they use light strokes rather than heavy ones.

Ask the children what happened when they combined yellow crayon marks and blue ones. They should say that the color changed from blue (or yellow) to green.

Encourage the children to combine other colors of their choice. Each child should be able to name the colors before and after they have been combined.

As an alternate activity you might give the children blue and yellow finger paints or tempera paints. Ask the children how they could make the color green. If they do not suggest combining blue and yellow paint, ask what happened when they combined blue and yellow solutions. Ask the children to try combining the finger paints. They should be able to state that when they combined blue and yellow paints, the colors changed to green.

Materials

Crayons, 1 box per child
White paper, 1 sheet for each child
Finger or tempera paints, 2 jars, one yellow and one blue

FIGURE 1

Activity 2

Divide the children into groups of three or four. Give each child a piece of Congo-red paper and a paste stick. Provide each group with two containers—a vinegar solution marked with a "V," and a baking soda solution marked with an "S." (See Figure 1.) Have the children dip their paste sticks into the vinegar and then touch the stick to the Congo-red paper. Ask them what they observe. (Where the paste stick touches the paper, the color changes from red to blue.) Let the children draw patterns on the Congo-red paper with the paste sticks dipped in vinegar.

The blue patterns on the Congo-red paper can be made to disappear if they are retraced with a paste stick that has been dipped in the solution of baking soda. Call the children's attention to the containers of baking soda. Have them dip their paste sticks in this new solution and retrace the blue patterns on the Congo-red paper. Ask the children what they observe. Do not tell them in advance what should happen.

Materials

Congo-red paper, 1 package (*Module 17*)
Containers, 20, 120-ml, clear plastic (*Module 17*)
Vinegar, 1 bottle, white (*Module 17*)
(Note: Make 1 liter of vinegar solution by combining equal quantities of vinegar and water.)
Paste sticks, 30 (*Module 17*)
Baking soda, 1 container (*Module 17*)
(Note: Make baking soda solution by dissolving 20 g of baking soda in 1 liter of water.)

Activity 3 (Optional)

Before class, prepare a solution of cobalt chloride. Use a paste stick to make letters, numbers, or patterns (circles, squares, triangles, and so on) with the solution on sheets of white paper. Then let all the sheets dry. Prepare at least one sheet for each child and one for you.

Ask the children to observe what happens when you warm one of the sheets over a light bulb or with an iron. They should say that the pattern made with the cobalt chloride solution changes from colorless or faint pink to blue. Help the children warm their sheets to reveal the patterns. *CAUTION: While heating their papers, the children should have adult supervision*. During the course of the day, all the children should have a chance to reveal the patterns on their own piece of paper.

Show the children the colored squares used during the *Introduction*. Ask the children which one is most like the color of the patterns on the paper. They should select the blue square.

The blue patterns can be made colorless by holding the paper over boiling water or by leaving it for a few hours in humid air.

Materials

Container, 1, 120-ml, clear plastic (*Module 17*)
Cobalt chloride, 1 container (*Module 17*)
(Note: Make cobalt chloride solution by dissolving 1 g of cobalt chloride in 50 ml of water.)
Paste stick, 1 (*Module 17*)
Lamp with 100-watt light bulb, 1, or an iron
White paper, 1 sheet for each child
Paper squares, 6, one of each color: red, orange, yellow, green, blue, and purple

Activity 4

The children will enjoy writing "secret" messages using lemon juice even though the messages they write may only be their names or the pictures they draw.

Using lemon juice, draw letters or shapes on white paper with a paste stick. Allow the paper to dry. Create some intrigue about the paper by talking about the invisible pictures and messages. Ask what the children think they would have to do in order for the writing to be seen. Hold the papers over a 100-watt light bulb or iron the papers. The designs should become visible in a light-brown color. (See Figure 2.) Talk with the children about the color change that occurred: about the color before the change and about the color after the change.

Give the children small amounts of lemon juice, paste sticks, and sheets of white paper. Ask the children to draw an invisible picture or to write an invisible message to someone. After the papers have dried, have the children deliver the messages to each other. Help the children heat their papers. *CAUTION: While heating their papers, the children should have adult supervision*. Again, discuss the designs and the changes that have occurred. Encourage the children to try the activity at home with the help of their parents.

Materials

Lemon juice, from 2 lemons
Containers, 10, 120-ml, clear plastic (*Module 17*)
Paste sticks, 30 (*Module 17*)
Lamp, with 100-watt light bulb, 1, or an iron
White paper, 1 sheet for each child

FIGURE 2

Activity 5

This activity provides the children with an opportunity to observe solids changing to liquids. You might arouse the children's interest in this topic after pointing out snow or ice on the playground. Or, you might introduce the topic by discussing what it is like to eat a popsicle or an ice cream cone. In the latter case some leading questions might be:

Why does ice cream melt on your tongue?
Does the ice cream change in shape as it melts?
Ice cream can drip. What about snow?

Give every child an ice cube on a paper towel. Ask one of the children if the ice will change. Ask the others how they know it will change. Be sure all the children have an opportunity to hold melting ice cubes so they will see liquid on their hand as well as on the remaining ice.

Place cubes of modeling clay, butter, and ice on a large hot saucer where the children can see them. Then ask the children to name each of the substances on the saucer. Have the children compare the size, shape, and color of the substances.

Some of the cubes will begin to melt as the children are comparing them. Let the children discover this themselves. Ask questions about the changes that are occurring as the ice and the butter melt. Introduce the words *solid* and *liquid* and encourage the children to use these words. Questions such as these may be helpful:

Which cubes are solid? Which ones are becoming liquid?
Which cube melts first? What happens when it melts?
Is the color changing? Is the shape changing?
What is happening to the cube of clay? Is it changing? Will it ever melt?
What will happen if we leave the saucer on the table overnight?
What will happen if we put the saucer in the refrigerator? Outside?
Will the melted shapes become cubes again?
Will the liquids become solids again?
Will any of the colors change?

Place the saucer in a cool place or in a freezer for an extended time. Then have the children observe and describe the changes that have occurred.

Materials

Ice cubes, 1 for each child and additional cubes for demonstration
Paper towels, 1 for each child
Clay, 1, 4-cm cube of modeling (*Module 17*)
Butter, 1, 4-cm cube
Saucer or earthenware plate, 1
(Note: Heat the saucer under a hot water faucet.)

Activity 6

Light a candle. Have the children observe the melting wax dripping on a cool surface and becoming solid again. Have the children touch the candle and the cooled drippings as shown in Figure 3.

Place about 10 grams of paraffin or old candle stubs in a small aluminum pan and heat it gently over a pan of boiling water on a hot plate. When the wax is melted, hold the pan by the edge with tongs and plunge it straight down into cold water in a container deeper than the pan, such as a sink, pail, or dishpan. You may want to wear rubber gloves for protection. The liquid wax will rise to the surface of the water and will quickly solidify into twisted shapes that the children will find interesting. (See Figure 4.) Have the children identify the liquid and solid phases of the wax and describe the changes that occur. The wax shapes might be used as part of an art activity. Display several different wax shapes and ask the children which they like best. Do some make them feel happy? Do some make them feel sad? Are some scary? Do some look as though they are moving? Although the shapes are a bit fragile, the children might try to take some of them home.

Materials

Candle, 1 (*Module 17*)
Matches, 1 package
Paraffin, 1 block, or old candle stubs (*Module 17*)
(Note: Remove the wicks from the candles.)
Pans, 3, aluminum, small (*Module 17*)
Pail, sink, or dishpan, 1
Pan, 1, of boiling water to hold pan of melting wax.
Hot plate, 1
Kitchen tongs, 1
Rubber gloves, 1 pair

FIGURE 3

Generalizing Experience

The environment inside and outside the school offers many opportunities for observing change. Have the children look for changes all around them—changes in color, size, shape, and changes from solid to liquid and liquid to solid.

Make some gelatin dessert as a group project. This activity will provide an opportunity to observe color changes and changes from liquid to solid. The class may have some interesting discussions trying to decide whether or not the gelatin is solid. Ask if the gelatin is keeping its shape when it "jiggles."

Expose peeled potatoes and apples to the air for some time and have the children observe the color change. The children might watch a dried resurrection plant "come to life" when it is placed in water. Its dried stems will uncurl and its leaves will turn green. Ask the children to describe the plant's changes in color, shape, and size.

Materials

Gelatin, 1 package, flavored (*Module 17*)
Container, 1, glass, for gelatin
(Note: You may wish to use small containers to make individual desserts, one for each child.)
Potato, 1 (optional)
Apple, 1 (optional)
Resurrection plant, 1 (optional)

FIGURE 4

APPRAISAL

Hold sheets of red, yellow, and blue acetate, one at a time, against the window or on the projection surface of an overhead projector. Ask the children to identify the colors and to predict what colors they will see if two of the sheets are combined. Try all possible combinations and discuss the changes the children see.

Place a square of chocolate in a glass baking dish. Ask the children what they think would happen to the chocolate if it were heated. They should predict the color, shape, size, and phase changes. Now place the dish in a pan of hot water and heat the chocolate. Let the children describe what they observe.

Ask the children what they think would happen to the melted chocolate if the dish were removed from the heat. They should predict that the chocolate would become solid again. Take the dish out of the hot water and set it aside to cool. When the liquid has solidified, show it to the children and have them describe what they observe. Ask if their predictions were correct.

Materials

Acetate sheets, 3, one each of red, yellow, and blue (*Module 17*)
Chocolate, 2 squares, semisweet baking
Container, 1, glass, heat resistant (*Module 17*)
Pan, 1, to hold glass container
Hot plate, 1

COMPETENCY MEASURE

Place four 30-milliliter containers on a table in front of the child. In one, place a few drops of bromothymol blue and fill with water; in another, place a few drops of red food-coloring and fill with water; in the third, place a small blue cube; and in the fourth, place any small object such as a nail, a spool, or a marble.

TASK 1 (Objective 1): Show the child the four containers. Say, **Point to the things that are solid.** Give the child time to respond and then say, **Point to the things that are liquid.** The child should correctly identify both the solids and the liquids.

TASK 2 (Objective 2): Place the container with bromothymol blue in front of the child and set the other three aside. As the child watches, add vinegar, drop by drop, to the solution as you stir it. The liquid should turn from blue to bright yellow. Ask, **Did the color change? What was the color before the change? What was the color after the change?** The child should name blue, as the color before the change, and yellow, as the color after the change.

TASK 3 (Objective 3): Place a sugar cube in a small custard cup or on an inverted aluminum pan. Point to the sugar cube and say, **This is a sugar cube. I am going to burn it, and I want you to tell me how it changes.** Add a few drops of lemon flavoring or some alcohol to the sugar cube and ignite it with a match. Allow the child to watch until the flame goes out and no further changes are occurring. Say, **Tell me what changed.** The child should describe at least two of the color, shape, size, and phase changes.

Materials

Containers, 4, 30-ml, clear plastic (*Module 17*)
Bromothymol blue, 1 container (*Module 17*)
Food coloring, 1 container, red (*Module 17*)
Cube, 1, 3-cm, blue (*Module 25*)
Object, 1, small, such as a marble, a nail, a spool
Vinegar, 1 bottle, white (*Module 17*)
Dropper, 1 (*Module 28*)
Ammonia, 1 bottle (*Module 17*)
(Note: After *TASK 2* the original blue color of bromothymol blue can be restored by adding a few drops of ammonia.)
Sugar, 1 package, cubes (*Module 18*)
Flavoring, 1 bottle, lemon (*Module 18*) or any flavoring with a high alcohol content
Pan, 1, aluminum, small (*Module 17*) or custard cup
Matches, 1 package

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17 Observing/g

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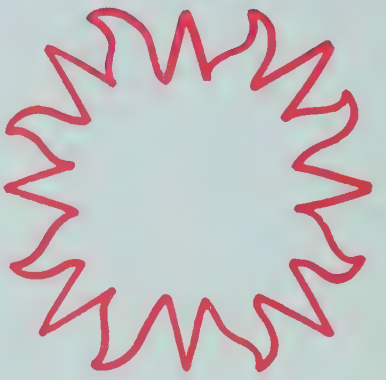

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SCIENCE... A PROCESS APPROACH II

MODULE

18

Observing/h

Using the Senses

OBJECTIVES

At the end of this module the child should be able to

1. *DESCRIBE* objects, or changes in objects, after making observations using several of the senses.
2. *IDENTIFY* which sense or senses are used to make an observation, by saying, for example, "I smelled it," "I saw it," and so on.

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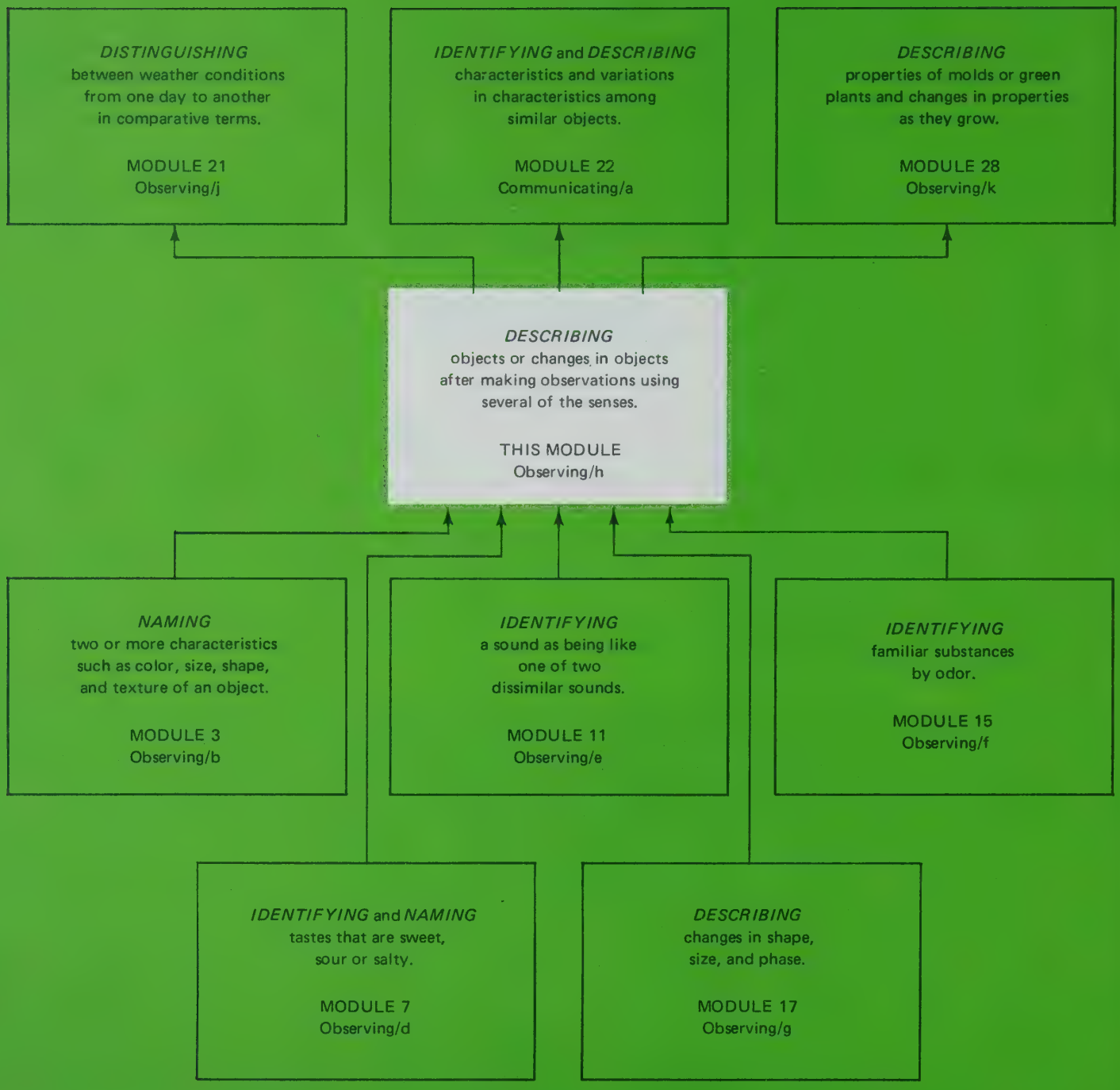

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RATIONALE

As children acquire the ability to make observations using several senses, they develop increased awareness of and sensitivity to things around them. Further, as they progress in their education in science, solving problems and answering questions, they will need to make use of one or more of the senses in whatever sequence is appropriate to the situation. Conscious cultivation of observing skills utilizing all of the senses should strengthen the children's ability to distinguish between observations and inferences and to construct inferences on the basis of their observations, and should help them avoid using inferences as if they were observations.

Encourage the children to identify which senses they use to make observations. Shapes, colors, and sizes can be distinguished and/or classified by means of the sense of sight; textures by the sense of touch; odors by the sense of smell; sounds or noise by the sense of hearing; and sweet, bitter, salty, and sour by the sense of taste.

Vocabulary

senses (optional)	feel
see	odor
taste	sound
hear	touch
smell	

INSTRUCTIONAL PROCEDURE

Introduction

As the children are finishing some other activity, have someone begin popping corn. Be sure that the children do not see the preparation or the corn popping. The sound and the odor should arouse their attention. Then ask questions such as these:

What do you think is happening?
What makes you think this is happening?
What did you observe first?

Materials

Popcorn, 1 package, uncooked
Electric popper, 1, or hot plate and pot with cover
(Note: Electric frypan works well also.)
Cooking oil, sufficient quantity to pop corn

Activity 1

Arrange for the class to watch corn popping. (See Figure 1.) Have the children discuss what they observe.

Show the children the popped corn, and let them touch it. Then show them unpopped corn, and let them touch this. Ask them what the corn looks like after it has been popped. Their descriptions may be very vague.

Give the children paper napkins and divide the popcorn among them. Encourage the children to see, to touch, to taste, and to eat the popcorn, if they wish. Ask the children what they noticed the first time the corn was popped. Some of the children might tell you they guessed that corn was popping before they saw it. Ask what made these children think corn was popping. Some will say, "I heard it." Others will say, "I smelled it." Some may insist that they smelled it before they heard it, but most will probably agree that they heard it first and smelled it afterward.

Ask the children to describe what their ears, nose, eyes, fingers, and tongue told them about the popcorn. Ask how the popcorn was different before and after it was popped.

Materials

Popcorn, 1 package, uncooked
(Note: Set aside a small bag of popped popcorn for *Activity 4*.)
Electric popper, 1, or hot plate and pot with cover
Cooking oil, sufficient quantity to pop corn
Paper napkins, several for each child, or paper towels

FIGURE 1

Activity 2

Draw on the chalkboard a large chart similar to that shown in Figure 2.

Ask a child to choose an item in the room. Then let everyone describe characteristics under the appropriate headings. If a ball is selected, one child might say, "I see that it is red." Write "red" under the picture of the eye. When another student says, "It feels soft," write "soft" under the picture of the hand. The children will enjoy seeing their own suggestions written on the board, but do not allow the activity to become a vocabulary lesson. Maintain a focus on the process of observing.

Some children may wish to bring interesting items from home for observation. You may wish to encourage them.

Activity 3

Before starting this activity, put some instant, dehydrated soup and water into a covered container without letting the children see what you are doing. When you are ready to begin the activity, slowly heat the soup where the children cannot see it. Someone will probably comment, "I smell soup cooking." Encourage the children to talk about why they think soup is being cooked.

Open a package of instant, dehydrated soup and let the children compare it with the cooked soup—in color, texture, smell, and taste. As you spoon some uncooked soup into one of the 30-milliliter containers and some cooked soup into another, have the children compare the sound that each makes. Let the children taste both the cooked and the uncooked soup, and compare them. Observations like these may be expected:

Uncooked soup feels rough.
Cooked soup feels smooth and slippery.
Uncooked soup looks like sand.
Cooked soup doesn't look shiny.
Uncooked soup tastes very salty.
Cooked soup tastes just right.

Point out to the children that they are making observations in several different ways: by describing what they see, what they feel, what they smell, and what they taste.

Materials

Dehydrated soup, several packets, instant
Saucepan, 1, with cover
Hot plate, 1
Spoon, 1
Containers, 60, 30-ml, clear plastic (*Module 18*)

OBSERVATIONS

ITEM					

FIGURE 2

Activity 4 (Optional)

This is an extension of *Activity 1*. You may want to use it particularly with children who want to know more about why the corn popped. Encourage the children's questions. You may want to use analogies and comparisons during the discussion of their questions. The children may be able to reason out answers to some of their questions if they participate in the activities that follow.

1. Why is there a noise when the corn pops? Blow up a paper bag, and pop it with your hand. The sudden release of pressure as the bag breaks produces a sound similar to the sound of an exploding kernel.

2. How much bigger does the popcorn get when it pops? Tell the children to line up ten unpopped kernels in a row. Alongside this row, have them line up ten popped kernels. Point out that this is one way of comparing the sizes of popped and unpopped corn.

Materials

Paper bags
Popcorn, 1 package, uncooked
Popcorn, cooked, from *Activity 1*

Generalizing Experience

You may wish to bake cookies with your class. Have the children identify the sounds of mixing and beating, the texture and appearance of the dough, the baking odors, and the taste of the dough. Keep one unbaked cookie to show the difference between the unbaked and baked cookies. Throughout the activity emphasize the importance of the five senses for making observations. If this activity is not practical, your children might discuss the senses they use when observing cooking at home.

Materials

Equipment and ingredients for making cookies

APPRAISAL

Without letting the children see what you are doing, add flavoring such as lemon or maple extract, drop by drop, to some sugar cubes until the cubes are saturated. After they have dried and hardened, place them in a box. Shake the box and ask the children what they observe. (Have them describe the sound made by the cubes.) Then, let each child take one sugar cube and observe it. Have the children tell what observations they have made and how they made the observations. You might ask questions such as:

How does the cube feel?
Does it have an odor?
What kind of odor?
How does it taste?

Materials

Small box, 1
Sugar cubes, 1 package (*Module 18*)
Flavoring, 1 container, such as lemon or maple extract (*Module 18*)

COMPETENCY MEASURE

TASK 1 (Objective 1): Show the child a marshmallow, and ask, What can you tell me about this marshmallow? Allow the child to touch, smell, and taste the marshmallow. The child should describe at least three of the marshmallow's properties, such as color, texture, taste, smell, and shape.

TASK 2 (Objective 1): Toast a marshmallow over the flame of a candle. Say, Tell me all the changes that you have observed in the marshmallow. The child should describe changes in at least three properties, such as color, texture, taste, smell, shape, and size.

TASK 3 (Objective 2): Ask the child, How did you observe these changes? The child should identify correctly which senses were used to observe each change described by making such statements as, "I smelled it," "I saw it," and so on.

Materials

Marshmallows, 2 for each child
Candle, 1, and matches
Skewer with wooden handle, 1, to toast marshmallow

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18 Observing/h

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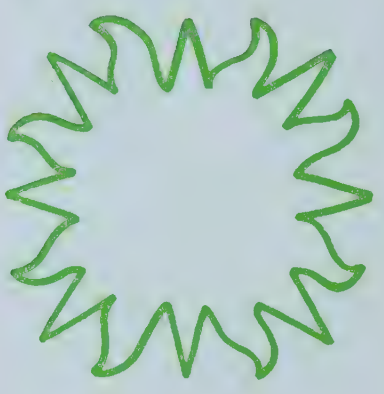

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SCIENCE... A PROCESS APPROACH II

MODULE

19

Observing/i

Soils

OBJECTIVES

At the end of this exercise the child should be able to

1. *IDENTIFY* objects, or changes in objects, after making observations using several of the senses.
2. *IDENTIFY* which sense or senses are used to make observations, by saying, for example, "I smelled it," "I saw it," and so on.

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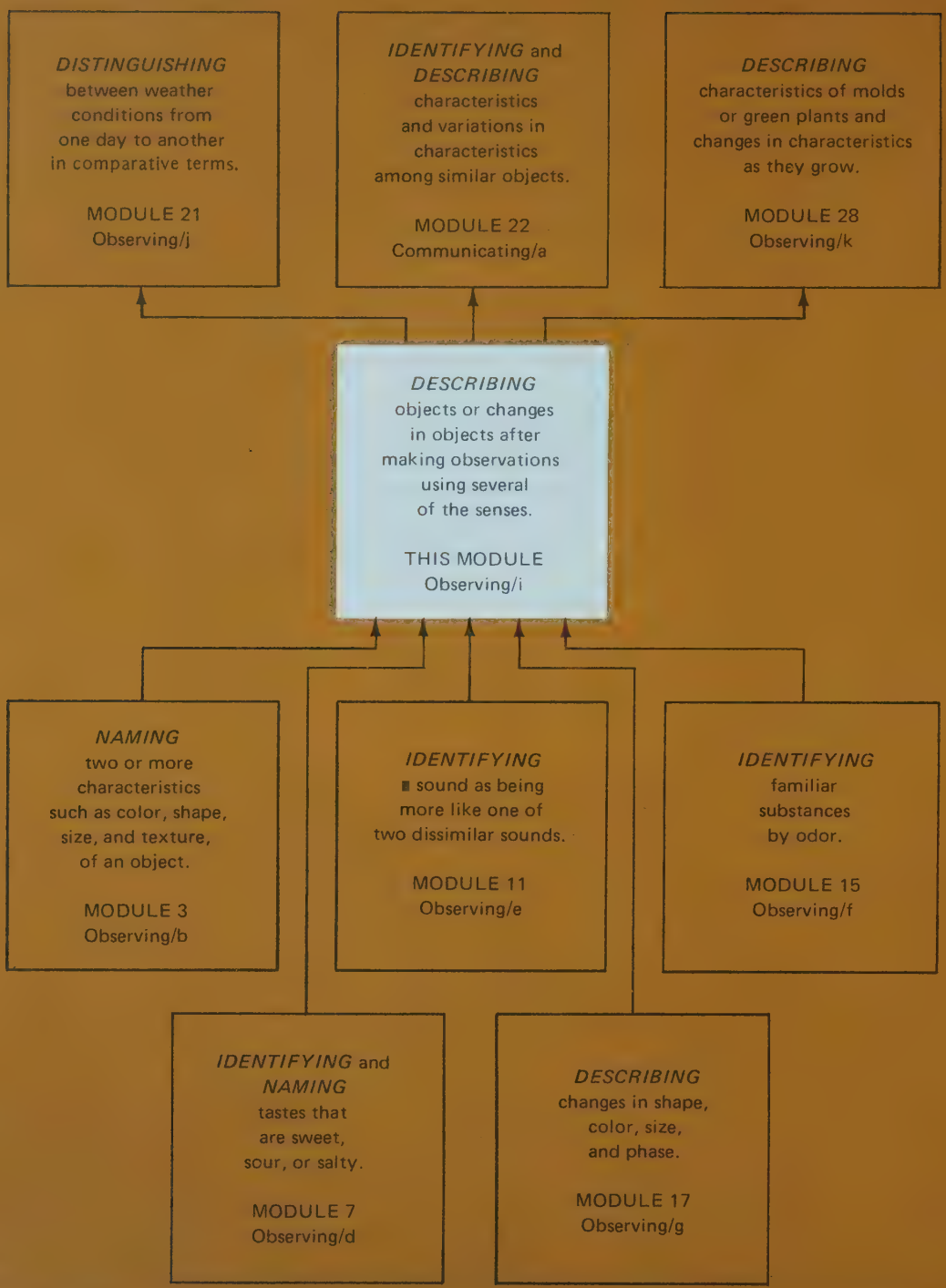
DISTINGUISHING between weather conditions from one day to another in comparative terms.
MODULE 21 Observing/j
IDENTIFYING and *DESCRIBING* characteristics and variations in characteristics among similar objects.
MODULE 22 Communicating/a
DESCRIBING characteristics of molds or green plants and changes in characteristics as they grow.
MODULE 28 Observing/k
DESCRIBING objects or changes in objects after making observations using several of the senses.
THIS MODULE Observing/i
NAMING two or more characteristics such as color, shape, size, and texture, of an object.
MODULE 3 Observing/b
IDENTIFYING ■ sound as being more like one of two dissimilar sounds.
MODULE 11 Observing/e
IDENTIFYING familiar substances by odor.
MODULE 15 Observing/f
IDENTIFYING and *NAMING* tastes that are sweet, sour, or salty.
MODULE 7 Observing/d
DESCRIBING changes in shape, color, size, and phase.
MODULE 17 Observing/g

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RATIONALE

This module provides additional opportunity for the children to make careful observations using several of the senses. Soils have been selected for study because they are readily available, are an important element of the environment, and are a concern of several fields of science, especially ecology.

The module must be adapted to local conditions. The procedures for the various activities will depend to a large extent on the kinds of soils that are available in your locale.

Throughout the module, whenever a child makes an observation, emphasize Objective 2 by having the child make statements such as, "I saw it," or "I smelled it," to tell you which sense was used to make the observation.

The *Introduction*, *Activity 1*, and *Activity 2* are designed to be performed sequentially. Thereafter, *Activities 3-7* may be performed sequentially or simultaneously. It is not necessary that all five of these activities be performed. Involve each child in at least one of them or in one that will provide a similar learning experience. If the children are divided into groups to perform the various activities simultaneously, give them the opportunity to report their activities and their findings to the whole group. Summarize their reports in tabular form, and, if possible, combine this part of the work with your mathematics program to illustrate the relationships of these two disciplines. After the children have completed *Introduction to Graphing, Communicating b, Module 25*, you may wish to ask them to graph some of the data they collect in these activities.

Vocabulary

soil	loam
hand lens	vermiculite (optional)
sample	erosion
sand	sod
clay	runoff
humus	sprout

Advance Preparation (Optional)

Activity 6 requires sod which you may wish the children to grow, if it is not available otherwise. The grass seed should be planted 2 to 3 weeks before the sod is needed. (See *Activity 6, Materials*.)

INSTRUCTIONAL PROCEDURE

Introduction

During this activity, the children observe and discuss soil in preparation for a more careful observation of their own soil samples in *Activity 1.*

In the room or preferably outdoors, place about 15 liters of soil in a bucket or carton, and invite the children to observe the soil. Encourage them to talk and ask questions about what they see, feel, or smell. (See Figure 1.) To keep the interest lively, you may need to ask a few questions such as: What is it? Where did it come from? What are we going to do with it? Do not answer the children's questions. For example, if a child asks, "Where did you get the soil?," you might parry by asking, "Where could it have come from?" If the children live in urban environments, you may want to spend some time discussing how soil is formed and where it comes from.

Materials

Plastic dropcloth or newspapers, on which to place the carton and/or soil
Broom, 1
Dustpan, 1
Soil, about 15 liters in bucket or carton

FIGURE 1

Activity 1

If the weather is favorable, conduct this activity outside. Have the children help with distribution of materials and cleanup.

Distribute the soil used in the *Introduction* to each child, giving each about 500 milliliters. Pour the soil onto a piece of newspaper or a tray at each child's work space. Some teachers may prefer to have the children work in groups of four or five, sitting in a circle on the floor with a large pile of soil to be shared. Have the children wear paint smocks or aprons to protect their clothing. Explain to the children that dirty hands and aprons are to be expected, but that they should work as carefully as possible. Suggest that the children let the soil trickle through their fingers, smell it, and listen to it as it falls on their desks.

Ask the children to share their observations. You might ask such questions as:

What do you see?
How does the soil feel?
Does it smell?
Can you hear it?
Shall we taste it? Why? Why not?

Elicit as many observations as possible. Help the children to understand why some of the statements that they make are not observations.

Give each pair of children a small hand lens. Ask the children to use the lens to examine the soil. Ask what can be seen now that could not be seen before.

What the child observes will depend upon the kind of soil you supply. Give special attention to local conditions. In some localities the soil will have small pieces of dried leaves and twigs, remains of small animals, and small stones in it. You may wish to suggest that the children separate the soil into two piles, one containing particles that were once parts of living things (leaves, sticks, wings of insects) and the other containing nonliving or "never-alive" materials (sand, gravel, rocks). In other soils, these kinds of particles may not be visible, even with a hand lens. Then the classification might be made on some other basis, such as size of particles.

Materials

Smocks, or aprons, 1 for each child
(Note: Adults' shirts put on backwards and buttoned at the neck make good coverups, too.)
Soil, about 15 liters
Hand lenses, 15 (*Module 19*)
Newspapers or 1 tray for each child
Container, 1, 500-ml, clear plastic (*Module 19*)

Activity 2

Walk through the school grounds, a vacant lot, a wooded area, or an open field where the children can stop to examine soil samples. Take a trowel and several plastic bags or other containers such as milk cartons for the collection of soil samples that can be studied indoors. Have children bring samples from home, also. In urban areas, the variety of samples (see *Materials*) may have to be supplied by the school.

During the walk, you will have an opportunity to teach children to respect the environment, both public and private. Be sure that the children take soil samples only from places where no harm will be done and no owner will object.

Number the collected, or supplied, soil samples and place them at various stations around the room. Ask the children to move in pairs from station to station looking for similarities and differences among the samples. Ask them to find answers to questions such as:

Which sample contains the largest particles?
Which is blackest? Reddest? Lightest?
Which has small, hard particles or grains?
Which has more twigs? More insect parts?
How did you find out?
Which of your senses did you use?

During a discussion of their observations, encourage the children to speculate about soil uses. You might incorporate questions such as the following into the discussion: Which soil is like that in a garden? In a flower pot? At the beach? At the park? Along a country road? On a tennis court? In a vacant lot?

Materials

Trowel, 1 or 2
Plastic bags or milk cartons
Container or pail, to hold plastic bags
Soil, variety of samples including sand, clay, humus, and loam

Activity 3

This is the first of five alternative activities. Involve each child in one of the activities or in another comparable activity.

Have the children work in the room or outdoors, if possible. Divide them into groups of five. Give each group a large flat-bottomed container, a container of water, five empty flower pots, five milk cartons, each filled with a different kind of soil or growing medium, and some small stones. Have the children pour water into the large container until the water is 4 centimeters deep. Next, have them hold two or three of the empty pots down in the container and then observe how the water moves into the pots. Have the children report what they observe. Be sure they include the observation that the water level inside each pot appears to be the same as that on the outside. The children may also observe the water level by looking for a water mark on each pot as it is removed from the container.

Next, have the children place small stones over the holes in the bottom of each pot. Have them fill each pot with a different kind of soil or growing medium, place the pots in the water again, and observe what happens. (See Figure 2.) If the pots are clear plastic (see *Materials*) the children may be able to see the water rising through the soil. Within a few minutes the top of the soil in most of the pots will become moist indicating that the water has risen in the soil to a level higher than the water level outside the pot. The children should observe that there are differences in rising time of the water for different types of soils. Suggest that the children arrange the pots in order from fastest rising time to slowest. Ask the children to discuss the possibility of growing plants in the various kinds of soil.

In one instance, in which sand, vermiculite, clay, humus, and yard "dirt" were used, water rose through the sand and vermiculite first, and through the clay last. When asked about the possibility of growing plants in these three growing media, children's answers included, "clay is too hard, plants can't live" and "sand makes plants too wet."

Materials

Containers, 1 for each group, large flat-bottomed, or roasting pans
Container, 1, for water
Flower pots, 30, plastic (*Module 19*), or clear plastic containers
(Note: The containers should be about 8 centimeters deep and 8 centimeters in diameter with drainage hole in the bottom.)
Milk cartons, 6 sets of 5 cartons each filled with a different kind of soil or growing medium
Small stones, to cover the bottom of each flower pot
Soils or growing media: sand, vermiculite, humus, and clay (*Module 19*), and potting soil

FIGURE 2

Activity 4

Take the children to the playground, a vacant lot, or to a pupil's yard to investigate how water sinks into different kinds of soil. There, find at least three kinds of areas:

1. A place where soil is packed down hard, perhaps on a footpath.
2. A grassy spot.
3. A place where soil is loosely packed, perhaps at the edge of a garden.

You may find other areas suitable for study.

Insert a can in the soil at each location by placing a board on the can and tapping the can down to a depth marked on the can as explained in *Materials*. (See Figure 3.)

Assign a group of children to each area. Give a member of each group 200 milliliters of water. At a signal, have each child pour 200 milliliters of water carefully but quickly into the can. Have the children in each group observe what happens to the water in the can.

While you wait for the water to pass through the soil, play a game in the area, but come back to examine the cans at frequent intervals. One child from each group might be chosen to watch the can and note when the water has disappeared. Ask the children such questions as: At which location did the water disappear first? Second? Next? Last? How do you explain what you have observed?

Materials

Cans, 6
(Note: Cut the top and bottom out of each can. Make a mark 2 cm from the bottom of each can. Soup cans work well.)
Board, 1, about 7 x 12 cm
Containers, 250-ml (*Module 28*)
Hammer, 1

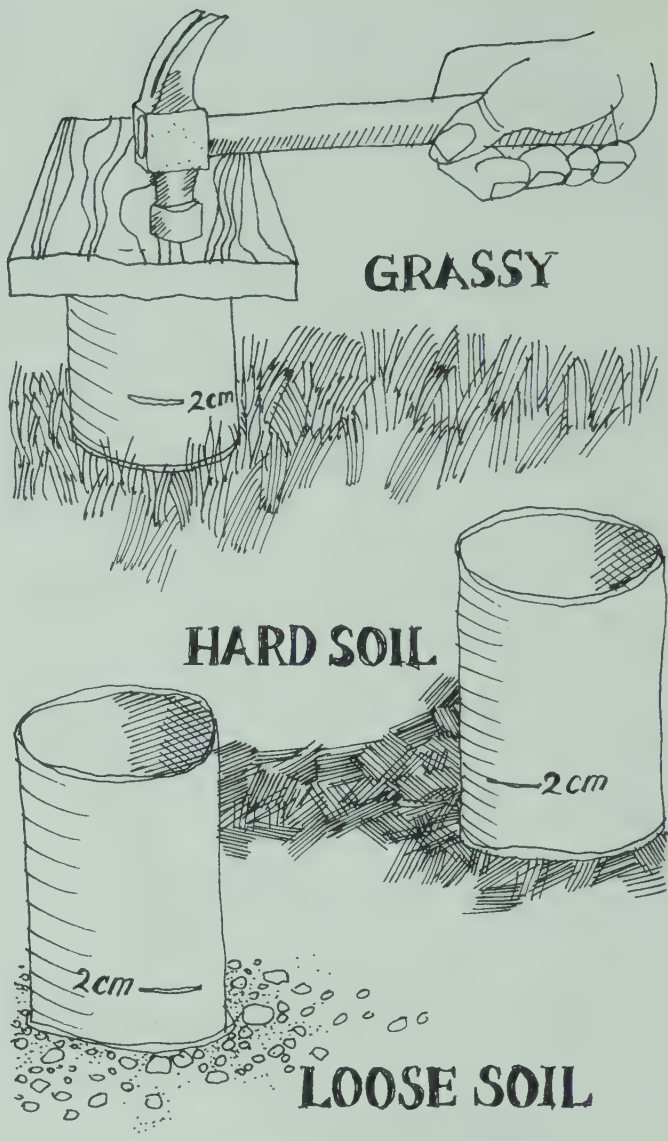

FIGURE 3

Activity 5

Have children work outdoors or, if necessary in the room. Provide pairs of children with four different soil samples—one of sand, one of vermiculite, and two others; a tray on which to work; newspaper with which to cover their desks; a 250-milliliter plastic container of water; and four 30-milliliter plastic containers in which to mix the water with the soil.

Have the children add a small amount of water slowly to each of the soil samples (See Figure 4). While doing this, the children should observe what happens by using four of their senses. Suggest that they seek answers to questions such as these:

How do the samples look when they are dry? When they are wet? What differences do you see?

How do the samples feel before and after water is added?

Do the samples smell the same after water is added?

Do you hear anything when water is added to the samples? Suppose your partner closes his eyes while you add water to each of the four samples, will he notice a difference in sounds?

FIGURE 4

Materials

Soil, or growing media, 15 sets of 4 samples: sand, vermiculite, humus, and clay (*Module 19*)
Trays, 1 for each pair of children
Newspapers
Paper towels
Containers, 15, 250-ml, clear plastic (*Module 28*)
Containers, 60, 30-ml, clear plastic (*Module 18*)

Activity 6

After a rainstorm, take the children on a walk around the school grounds or take them on a bus trip to see evidence of soil erosion. Generally soil will run from the grassed or semi-grassed areas onto the sidewalk or driveway after a rain. More dramatic evidences of erosion are visible in an eroded soil bank. Ask the children where the soil comes from and where it goes.

A poor substitute for seeing evidences of erosion firsthand, but better than seeing none, is to show children pictures or slides of eroded hillsides or fields. Discuss erosion and then suggest to the class that they perform the investigation that follows to show how erosion occurs.

Divide the class into groups, each of four and five children. Give each group two pans, loose soil to fill one pan, sod to cover the other pan, and a sprinkling can. If sod is not available, have the children grow the sod by planting grass seed several weeks before the sod is needed. The investigation may be initiated when the grass is 5 or more centimeters tall.

Raise one end of each pan—one covered with soil, one covered with sod—so that they represent hills. Set the other end of each pan in a tray or other container to collect the runoff. Have the groups water each "hill" with the same amount of water and observe what happens. (See Figure 5.) Allow the soil in the runoff to settle. Ask such questions as: Which pan lost the most soil? Why? How do grass, trees, and other plants help to prevent erosion?

The children can conduct a similar investigation using two kinds of soil for comparison instead of soil and sod. They might find out if some kinds of soil wash away faster than others. Have them record and report on what senses they used to make their observations.

Still another variation of the investigation is the construction of a stream valley. Line a shallow, corrugated cardboard box with plastic or foil. Place gravel and sand over the plastic or foil, add a layer of soil, then position plants in the soil. Bury ice cubes in the soil to provide a source of stream water.

Materials

Picture cards, 4, showing several types of water erosion (*Module 19*)
Pans, 2 for each group, having four low sides (Note: Cookie pans work well.)
Potting soil, 1 large bag
Sprinkling cans, 2-4
Blocks, 2 for each group
Grass seed, 1 bag (*Module 19*), or sod
Trays, 2 for each group, to catch runoff
Cardboard box, 1
Plastic wrap or aluminum foil, 1 roll
Sand, 1 bag
Gravel, 1 bag
Plants, several
Ice cubes, 2 trays

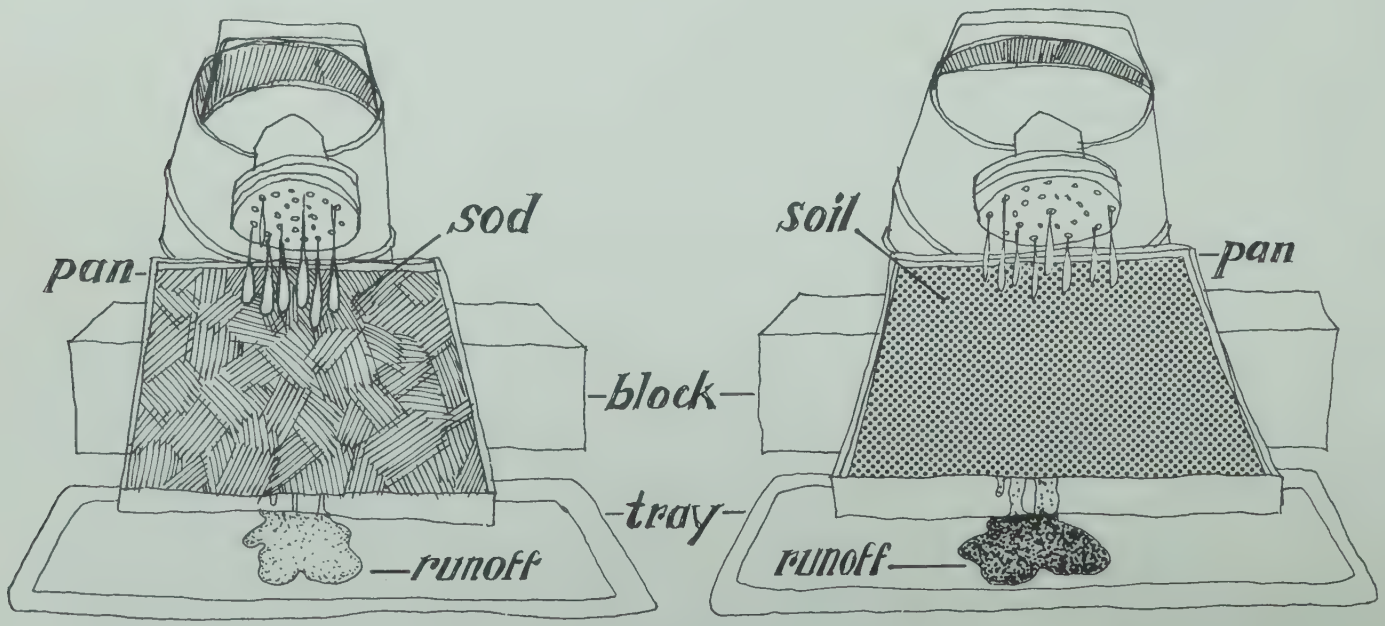

FIGURE 5

Activity 7

Talk with the children about the soil in which seeds grow. You might ask such questions as: Do seeds grow on the playground? In the woods? On the beach? In your kitchen? Ask what things determine how well seeds grow.

Plant radish or mung bean seeds in pots containing different kinds of soil samples. Number the pots, place them on trays of gravel, and put them where they will receive indirect light most of the day.

Guide the children in keeping as many variables constant as possible. For example, direct the children to use identical pots, to plant the same number of seeds in each pot, to plant the seeds to the same depth in each soil sample, to place each pot where it gets the same intensity and hours of sunlight, and to give each pot the same amount of water. Only the soil sample should vary.

Ask the children to observe when and how the seeds sprout. Ask if there is a difference in the sprouting depending on the soil sample. (Probably not.) The difference will show up as the seedlings grow. For example, since the sand and vermiculite have little nutrient content, plants in these soils will show a decreased rate of growth three or four weeks after sprouting. Have the children keep a class record of the growth of the plants, as shown in Figure 6.

Materials

Mung bean seeds, 1 package (*Module 19*), or radish seeds
Soil or growing media: sand, vermiculite, humus, and clay (*Module 19*), and potting soil
Container, 1, 30-ml, for measuring water for plants (*Module 18*)
Flower pots, 30 *(Module 19),* or empty milk cartons (Note: Put drainage holes in the milk cartons.)
Trays, several, on which to place flower pots
Gravel, 1 bag (*Module 19*)

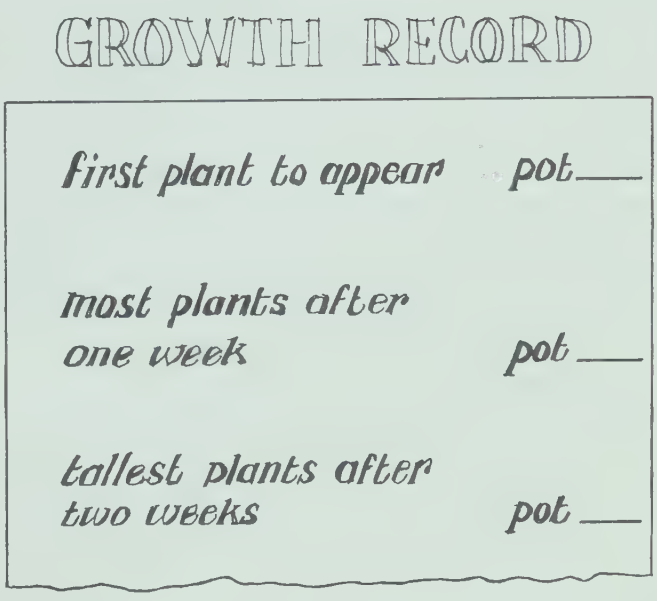

FIGURE 6

Generalizing Experience

In the following activity, students can participate individually, however the procedures described are for groups of children.

On each of two or three tables in front of the room, place samples of food products that are in particle form. Choose five products from those listed in *Materials*. Include only those items that can safely be tasted. As you label the items by number or color, tell the children what they are.

Divide the class into groups, one for each table. Invite each group to observe each sample carefully using all five senses. Use this opportunity to emphasize that the children should taste a substance only if they are certain that a substance is not harmful. As they circle the table, have each child in turn first taste the samples and then make their other observations. In this way the children will be tasting the samples before they touch or smell them. Tell them you want them to decide which two samples are least alike.

Suggest that the groups discuss their observations and identify which sense they used to decide which samples are least alike. It is not necessary and probably not desirable that a group reach a consensus regarding either the sample or the sense utilized. Next, have the groups develop a scheme to classify the remaining samples. Ask which sense the children used to classify each remaining sample.

Materials

Containers, 5, 250-ml, clear plastic *(Module 28)*
Food samples, brought from home, 100 ml of each food:
corn meal, corn starch, flour, salt, cake mix,
powdered sugar, granulated sugar, and brown sugar

APPRAISAL

Without letting the children see what you are doing, put about six cubes or six pebbles in a small covered can. Show the children the can and ask what they know about its contents. Now shake the can, and repeat the question. Ask the children what they would suggest doing to find out more about the contents. They will probably want to smell, touch, and look. Have the children follow through on their suggestions. The children should indicate that they recognize the importance of using general senses in getting information.

Materials

Small can, 1, covered
Cubes, 6 (*Module 30*), or pebbles

COMPETENCY MEASURE

TASK 1 (Objective 1): Blindfold the child and hand him an apple. Say, **Tell me all the things you can find out about this object without looking at it. You may taste it if you like.** The child should feel, smell, and taste the apple and say that it is smooth, smells like an apple, and tastes like an apple.

TASK 2 (Objective 1): Keep the child blindfolded and say, **I have a spoonful of something for you to taste. Tell me what it tastes like.** Put a spoonful of applesauce in the child's mouth. The child should say it tastes like apples or applesauce.

TASK 3 (Objective 1): Remove the blindfold and let the child see the apple and applesauce. Say, **Tell me in what ways the applesauce is different from the apple. You may use any of your senses.** The child should describe at least three differences such as differences in texture, aroma or color.

TASK 4 (Objectives 2): Say, **Tell me what senses you used to decide how the apple and the applesauce are different.** The child should identify the senses appropriately either by naming them (sight, touch) or by making statements such as, "I saw them," "I smelled them," and so on.

Materials

Blindfold, 1
Apples, 1 for each child
Applesauce, 1 jar
Spoons, 3

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19 Observing/i

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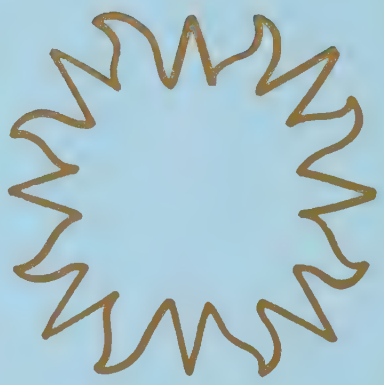

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SCIENCE...
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MODULE
20

Using Numbers/c

Counting Birds

OBJECTIVES

At the end of this module the child should be able to

1. *NAME* points on the number line using the whole numbers $^{-}9$ to *9*.
2. *IDENTIFY* and *NAME* any member of the set of whole numbers from $^{-}9$ to *9*.

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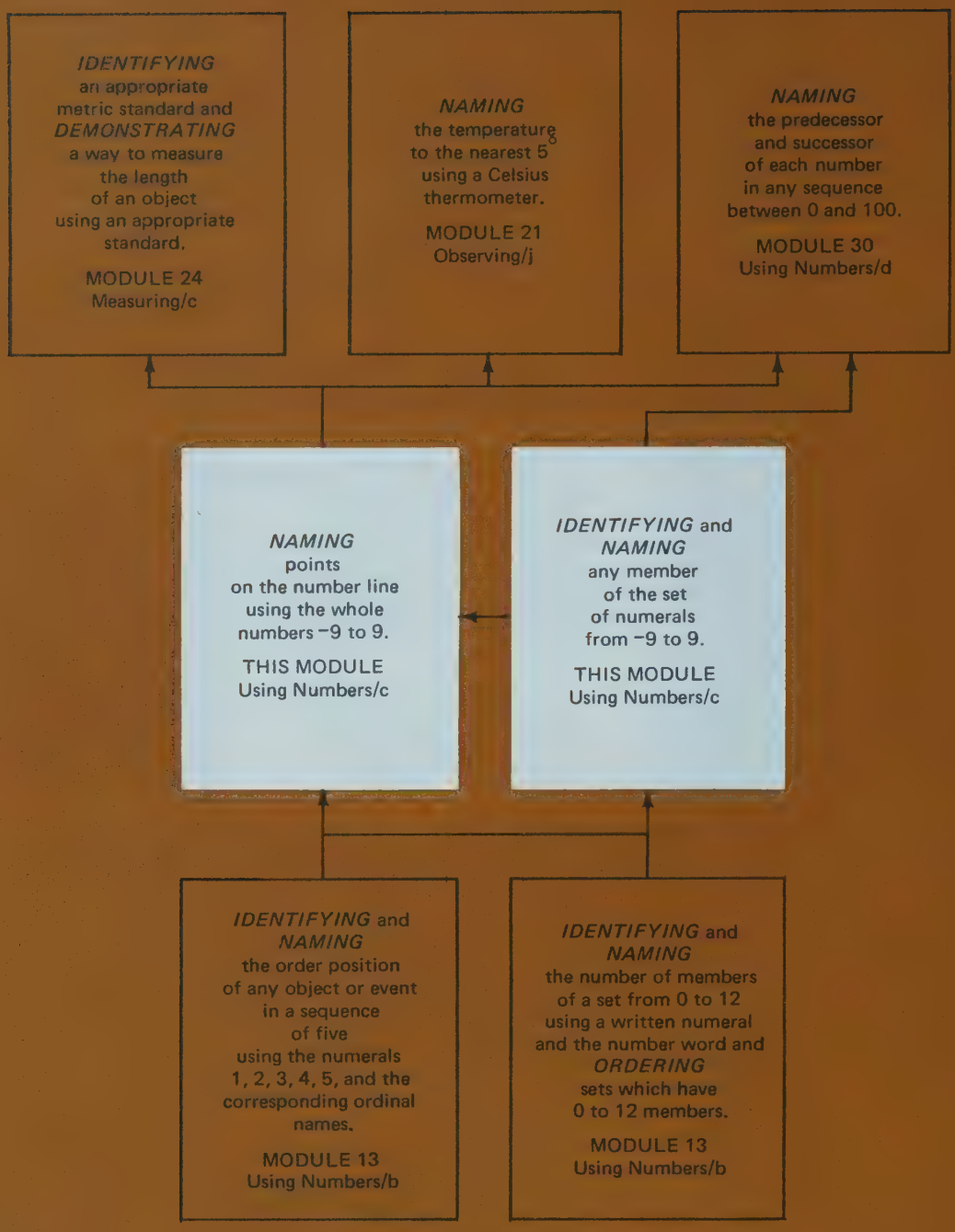
SEQUENCE


IDENTIFYING an appropriate metric standard and *DEMONSTRATING* a way to measure the length of an object using an appropriate standard.
MODULE 24 Measuring/c
NAMING the temperature to the nearest 5° using a Celsius thermometer.
MODULE 21 Observing/j
NAMING the predecessor and successor of each number in any sequence between 0 and 100.
MODULE 30 Using Numbers/d
NAMING points on the number line using the whole numbers −9 to 9.
THIS MODULE Using Numbers/c
IDENTIFYING and *NAMING* any member of the set of numerals from −9 to 9.
THIS MODULE Using Numbers/c
IDENTIFYING and *NAMING* the order position of any object or event in a sequence of five using the numerals 1, 2, 3, 4, 5, and the corresponding ordinal names.
MODULE 13 Using Numbers/b
IDENTIFYING and *NAMING* the number of members of a set from 0 to 12 using a written numeral and the number word and *ORDERING* sets which have 0 to 12 members.
MODULE 13 Using Numbers/b

Use of this chart, the instruction booklet, and other elements of **Science. . .A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

In this module the children are introduced to the number line, an important concept in science and one that is appropriate to introduce to young children. The scales of measuring instruments, such as thermometers and speedometers, represent number lines. The ability to use number lines is essential for graphing. Children will soon learn to make graphs in *Introduction to Graphing, Communicating b, Module 25* and will make and use graphs in many later modules.

On a number line, numbers are associated with points or positions. When one point on a number line has been named, a unit length chosen, and a positive direction designated, a one-to-one correspondence is established between numbers and the points of the line, such that each point corresponds to one and only one number and each number corresponds to one and only one point.

In this module, equally-spaced points on the number line are associated with whole numbers. In *Metersticks, Money, and Decimals, Using Numbers e, Module 59*, the children learn to associate decimal numbers with points on the number line that are between whole numbers.

Negative numbers are introduced in this module to fulfill a simple need; the numbers are needed so that positions on the number line in both directions from 0 can be given number names. The children are led to discover this need for themselves; in this way, the concept of negative numbers develops naturally. The children view negative numbers as position "namers". In regions that have cold climates, children can understand negative numbers as the "namers" of positions on the thermometer scale that are below 0 degrees.

Vocabulary

number line	negative six
negative one	negative seven
negative two	negative eight
negative three	negative nine
negative four	numeral
negative five	zero

INSTRUCTIONAL PROCEDURE

Introduction

Select nine children. Give each child a card on which one of the numerals *1* through *9* is printed. Ask these nine children to arrange themselves side by side at the front of the room so that the numerals on the cards will describe the position of each child in the row. Ask questions such as the following:

What number is between *5* and *7*?

What numbers are between *3* and *7*?

Make a line on the floor with masking tape or with chalk. The line should be approximately 5.5 meters long. Mark nineteen points on the line, each point about 30 centimeters from the next one. This provides enough space for a child to stand on each point marked on the line. Now label nine points on the line by using the numeral cards *9, 8, 7, 6, 5, 4, 3, 2,* and *1*. The numeral *9* should be given to one of the end points. Call this line a *number line.*

Ask a child to stand on the point named with the numeral *5* and to take three steps, walking in the direction of numeral *9*. (See Figure 1.) Each step should be on the

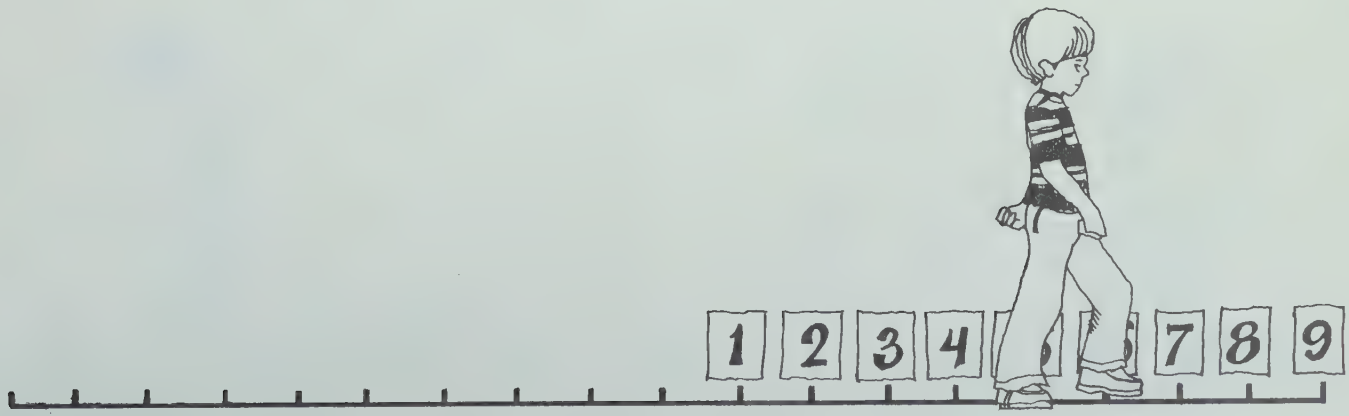


FIGURE 1

next point on the number line. Ask such questions as these:

What numeral will you stop on after you take three steps?

Where would you be if you had taken steps in the opposite direction?

Repeat the directions and the questions with several different children. Have one child start at some numeral and move to a point that has not yet been assigned a numeral.

Continue to label the remaining points on the number line by using a procedure such as the following. Ask the children what numerals are used to label the points on each side of *1*. They will quickly name one point *2*. Naming the point on the other side may be more difficult for them. Some children may suggest that it has not been labeled or named. With additional questions, elicit the idea that the point is usually labeled *0* and named *zero*.

Now ask the children to name the points next to zero. The children will say that one point is *1* and that no name has been given to the other point next to *0*. Ask for suggestions. You might ask how the point is like the point named "1" and how it is different. Someone should say that the point is on one side of *0* and just as far away from *0* as point *1*. The difference is that the point is on the other side of *0*, in the *opposite direction.* A child may suggest that the numeral *1* could be used to name this point if there was something else to show that it is *1* in the other direction. Let the children follow up on this suggestion. They may propose symbols such as these:

After the suggested symbols have been thoroughly discussed, tell the children that the numeral $^{-}1$ is usually used and that it is named *negative one.* Place the numeral card $^{-}1$ on the number line. You may wish to introduce the numeral $^{+}1$ and the name *positive one* at this time; however, the positive sign and the word *positive* are not used in *Science . . . A Process Approach* for members of the set of positive numbers. It is probably best that you not introduce the positive sign unless the children suggest that the numbers on the other side of *0* should also have some way of showing their direction.

Have a child take two steps from *0* to *2* and then two steps from *0* in the opposite direction. Ask the children how to label this point. After they have agreed upon $^{-}2$, and have called the numeral *negative two*, label the point with the numeral card. Repeat a similar procedure until all of the points to $^{-}9$ have been labeled. After four or five of the points are labeled, the children will probably want to label the remaining points to $^{-}9$ without taking the steps. Emphasize that *9* is nine steps from *0* in one direction, and that $^{-}9$ is nine steps from *0* in the opposite direction. (See Figure 2.)

Repeat this activity several times with the line in different orientations on the floor, and with the negative numerals sometimes on one side of *0* and sometimes on the other.

Materials

Numeral cards, 19, numbered from $^{-}9$ to *9*, one card for each numeral (*Module 20*)

Masking tape or chalk

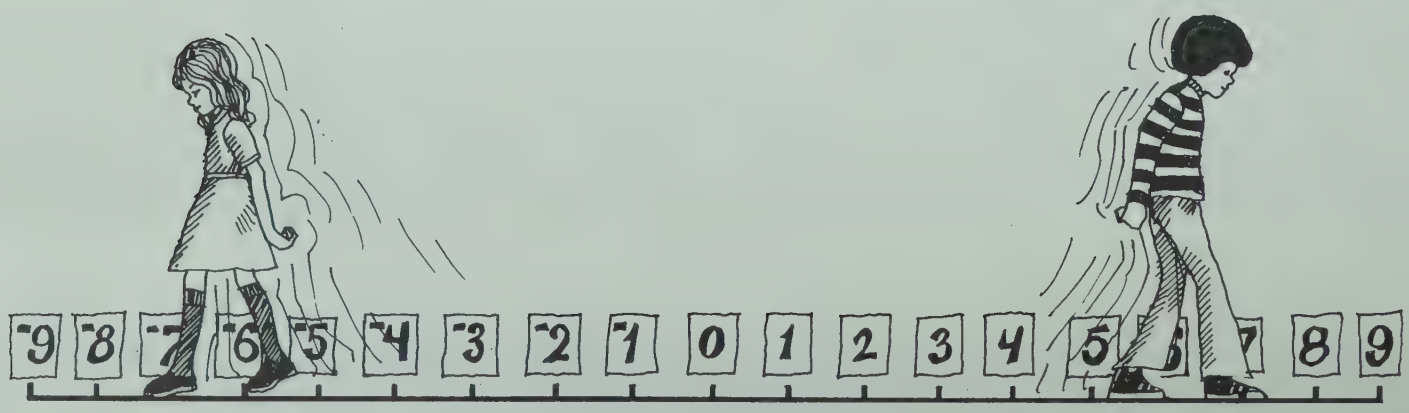


FIGURE 2

Activity 1

Ask the children if they have ever seen birds lined up on the limb of a tree, on a telephone line, or on a wire fence. Ask them if they tried to count the birds along the row. After having several individuals share their experiences with the group, show them a picture of ducklings lined up behind the mother duck, or a similar picture of animals in a row. Someone will probably suggest that animals in a picture are easier to count than those that are alive and moving. Have the children count the animals from left to right along the row. Ask the children to bring similar pictures of animals in a row for a display on the bulletin board.

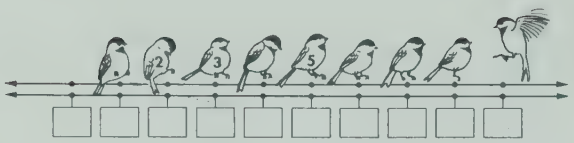
Working with a group of 12 or fewer children, give each child a copy of *Counting Birds,* a pencil, and a magic pen. Explain to the children that you are going to read the instructions for the sheet to them. Rhyming verses are included in the instructions. Several verses end with a number that the children are to call out. You may need to explain that the correct number, which is required to complete the verse, rhymes with the last word of the second line of the verse. You will probably want to prepare the children by asking them what number rhymes with *door,* with *blue.* They should then follow your instructions to locate either the bird or its name tag with the magic pen. You might give them short instructions to direct their attention to each bird line and hence to the corresponding number line below it. Figure 3 illustrates the sheet *Counting Birds* and Figure 4 shows it correctly completed.

You may want to demonstrate how the magic pen is to be used. The children should be encouraged to sweep the tip of the marker lightly over the space they wish to "color" or mark. If you prefer to have the children work individually or in small groups, it will probably be helpful if you make an audio tape of the verse and the instructions that follow on the next page.

FIGURE 3

FIGURE 4

Look at the line of chickadees.



Eight little chickadees
Standing on a line.
One flew in and joined them
And it was Number_____.

The new bird is on the bird line.
The magic pen will help you find its name.
Color the breast of the flying bird.
Its name tag is right below it on the number line.
Color the name tag and the name will show up.

One little chickadee
Always has to wait.
Standing next to Number 9
Is one named Number_____.

Color the breast of this bird with your magic pen.
Color the bird's name tag on the number line.

This little chickadee
Has a lot of fun.
Standing right by Number 2
You'll find a Number _____.

Color the breast of this bird.
Color its name tag.

One little chickadee
Just flew in from heaven.
Standing next to Number 8
You'll find a Number_____.

Color the breast of this bird.
Color its name tag.

Which little chickadee
Made its nest of sticks?
Standing next to Number 5
The one named Number _____.

Color the breast of this bird.
Color its name tag.

Another little chickadee
Just flew in the door.
Standing right by Number 3
You'll find a Number_____.

Color this bird's breast.
Color its name tag.

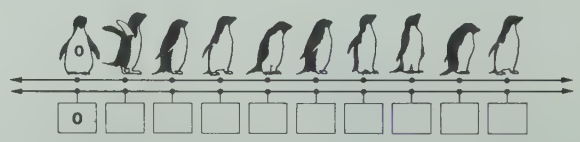
Of all the little chickadees
One was quite a hero.
To start with it and find the rest,
Begin with Number _____.

Color the place where the hero sits.
Color its name tag.
Now, name all the chickadees 0, 1, 2, 3, 4, 5, 6, 7, 8, 9.

Start with 0
And you will find
Each in the same place
Every time.

Color the name tag of each chickadee as you count it.
Did you notice that all the birds stand the same distance apart?
You can find each one by counting if you know just where to start.

Now, look at the turkeys standing on a line.
There are some other turkeys on the line, but they are hidden.
Color the breast of one of the two turkeys.
Color its name tag.
What is its name?
Count right two and then left two from the turkey you colored.
Then color those places on the bird line.
What did you find?
Color the name tags of the turkeys.
Did you find the numbers that you thought you would?
If someone tells you where to start and in which direction to move, you can find any bird you choose.



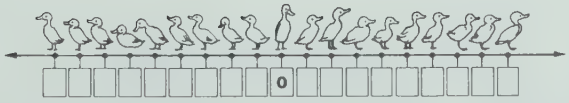
Look at the penguin named 0.
Start with 0.
Find all the other penguins by counting.
Use the magic pen to color them.
Are their names what you thought they would be?
Start with 0 on the number line.
Find the name tags by counting.

Color the name tags.
Are the names right?
Now draw a line between Penguin 0 and its name tag.
Do this for all the other penguins.

Materials

Pictures of animals in a row
Counting Birds, 1 spirit master (*Module 20*)
Magic pens, 12, image developers (*Module 20 and Module 30*)
Pencils, 1 for each child

Find the line of road runners.
See the bird on the other side of 0?
The new bird's name is Negative 1.
What is different about its name?
Color the breast of Negative 1.
See how we write its name.
Color the name tag.
Did you find Negative 1 where you thought you would?
Now start with 0 and name all the negative birds.
Their names and their standing places are the same.
Make sure you use the word "negative" when you name this set of road runners.
Color the breasts of all the road runners.
Say their names as you see them.
Color their name tags.
Now with your magic pen draw a line between Road Runner 0 and its name tag.
Do this for all the other road runners.
Since their names and their standing places are all the same, you really need only a number line to play *Counting Birds.*



Look at the line of ducks.
Color the name tag under these birds:

Negative 1
Negative 9
Negative 8
The bird that made its nest of sticks.
The bird that always has to wait.

Can you name all the other places?
Color those name tags.
Are the names what you thought they would be?

Activity 2

When the children have completed *Activity 1*, give them the materials and the directions for playing *Birds on a Line.* This game can be played by one child or by two children. Each game consists of a gameboard, a latent image number line, and a set of 19 cards, each with a picture of a bird. The object of the game is to collect the highest number of cards by correctly naming the positions of numbers on the number line.

You may wish to give the directions for the game in one of two ways: either read them to one child and have this child explain the game to other children, or record the directions on an audio tape for the children to use as needed.

Directions for a Single Player

Look at the game board. You see a line stretching across the board. There is a bird above each dot on the line. Slip the number line under the flap on the board so that the numeral *0* on the number line is right under the *owl.* (See Figure 5.) Use a paper clip to fasten the paper strip in place.

Now look at the deck of cards. Each card has a bird's picture on it. Shuffle the deck of cards. Mix them all up! Next, place all the cards, face-side down, in a stack. You shouldn't be able to see any of the pictures on the cards.

Take the top card from the deck. Look at the picture of the bird on the card. Try to find that bird's picture on the game board. In the circle on the number line below the bird's picture, write the numeral that names the bird's place on the number line. DO NOT WRITE IN THE SQUARE! Remember that "counting" numbers are on one side of zero; negative numbers are on the other side. After you have written your answer in the circle, rub your magic pen on the square to check your answer. If your answer is right, keep the card. If your answer is wrong, put your card in the throwaway pile.

Now take another card and follow the procedures again. The game is finished when the number line is complete—when all the circles and squares have numbers in them. Your score is the number of cards you keep. The highest possible score is 18.

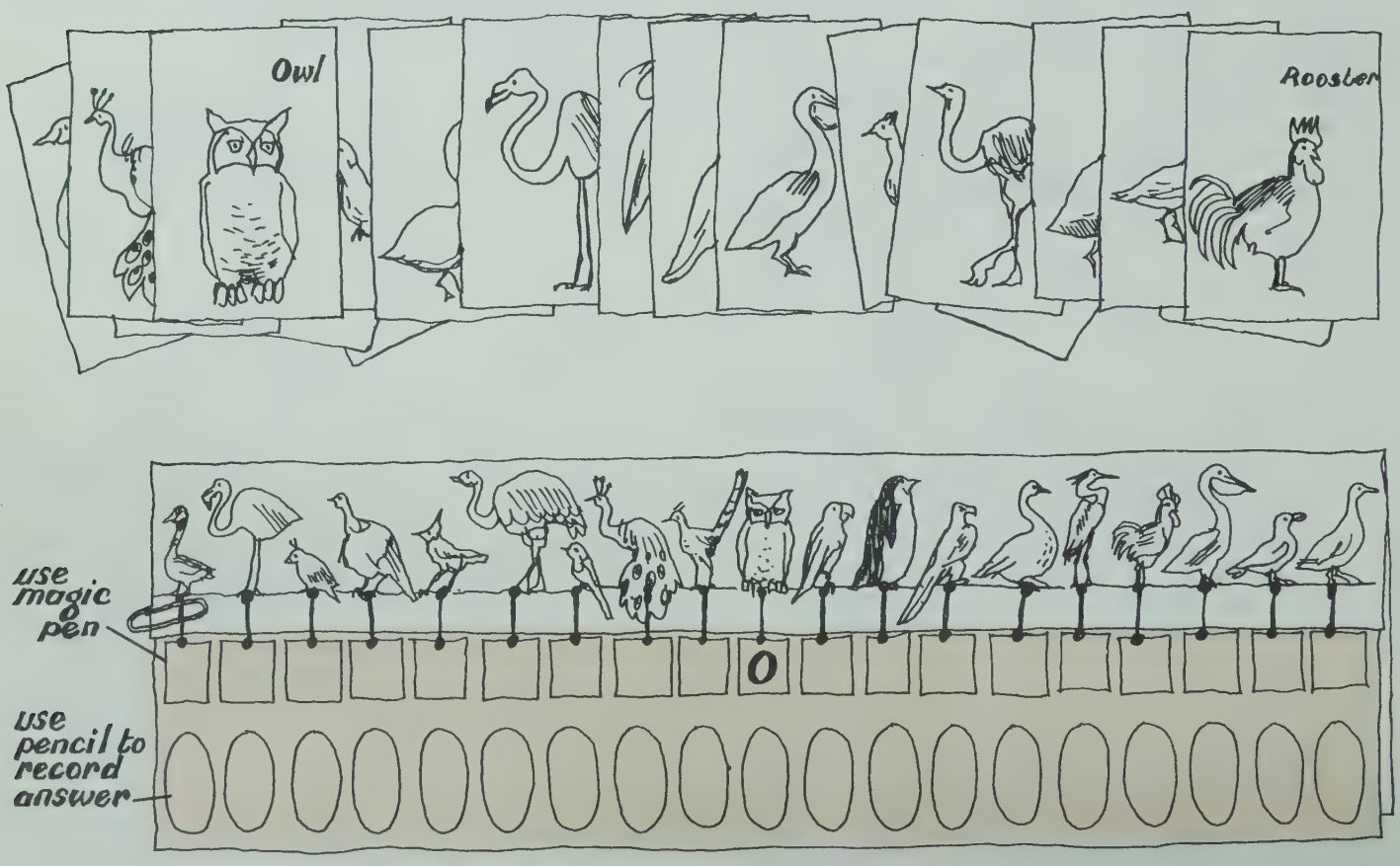


FIGURE 5

Directions for Two Players

The game is played by two players in much the same way as by a single player. The player first flips a coin to see who draws a card first. They then take turns drawing cards until every card is drawn and played. Each player matches his card with a picture of a bird on the game board, writes in the numeral on the number line, and checks it with the magic pen. The player then keeps the card if his answer is correct or puts the card in the throwaway pile if he makes a mistake. The play then passes to the other player. The game continues until all of the cards have been played, and all of the positions on the number line have been named. The individual score is found by counting only the cards each player is able to keep. The winner is the player with the higher score.

For either type of play, a new game can be started by turning in the number line to the teacher in return for a new one. The children may want to make new rules and play a different game using the same materials that are used to play *Birds on a Line.* As the children develop skill in playing the game, you might introduce this modification. Suppose the first card that the first child draws is the peacock. Move the number line until *0* is under the peacock. Use a paper clip to hold the strip in position. Notice that the number line does not extend beneath the sea gull and the duck now. (See Figure 6.) If the children draw these cards, they should discard them and draw again.

Materials

Birds on a Line, 4 game boards (*Module 20*)
Birds-on-a-Line Number Lines, 1 spirit master with latent image numbers (*Module 20*)
Bird cards, 4 sets of 19 cards (*Module 20*)
Magic pens, 12, image developers (*Module 20 and Module 30*)

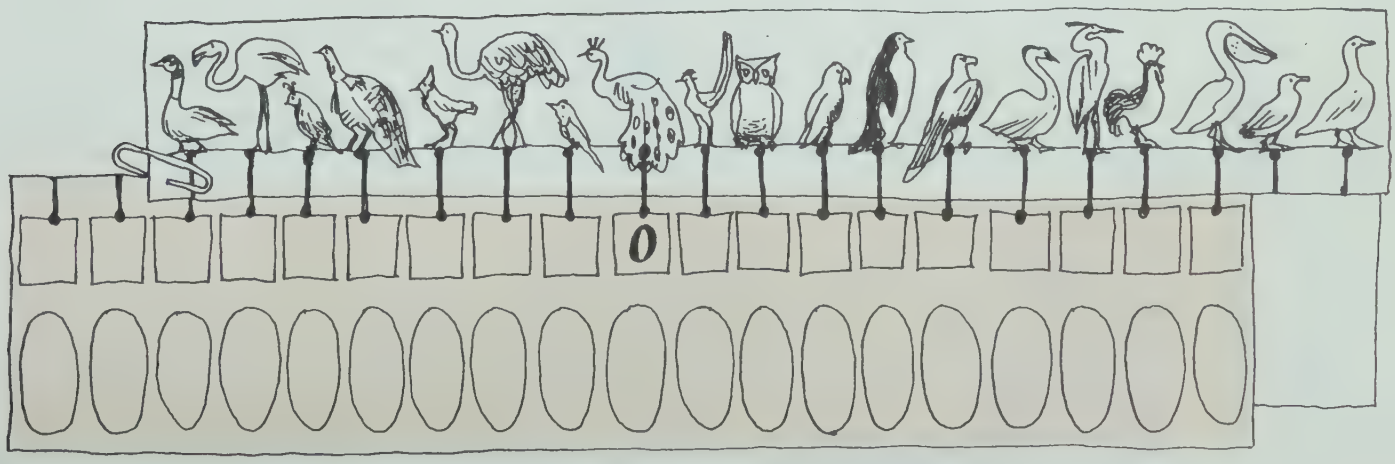


FIGURE 6

Generalizing Experiences

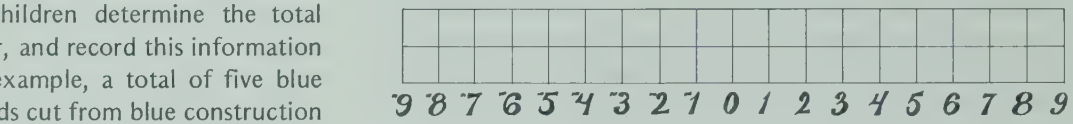
Have the children keep a record of the number of birds of different colors that they see on a given day. Let them decide what color is predominant for multicolored birds. On a bulletin board construct a number line on which the children can record their data. For each bird sighted, have the children cut out a bird from construction paper of the same color. Have the children determine the total number of birds of each color, and record this information on the number line. If, for example, a total of five blue birds were sighted, the five birds cut from blue construction paper should be placed above the *5* on the number line (Figure 7). This might be an on-going activity throughout the year. It not only reinforces the concept of the number line, but also serves as an introduction to skills utilized in graphing.

Give each child a strip of graph paper. Ask the children to use the edge of the markings on the paper as a number line and to mark the point in the middle of the strip with the numeral *0*. Then have the children mark the other lines with the whole numbers from $^{-}9$ to *9*. (See *Materials*.)

Materials

Number line, constructed on bulletin board
Construction paper, 1 package, several sheets of each color
Graph Paper, 1 spirit master (*Module 20*)

(Note: For each child, cut a strip of graph paper as shown below.)



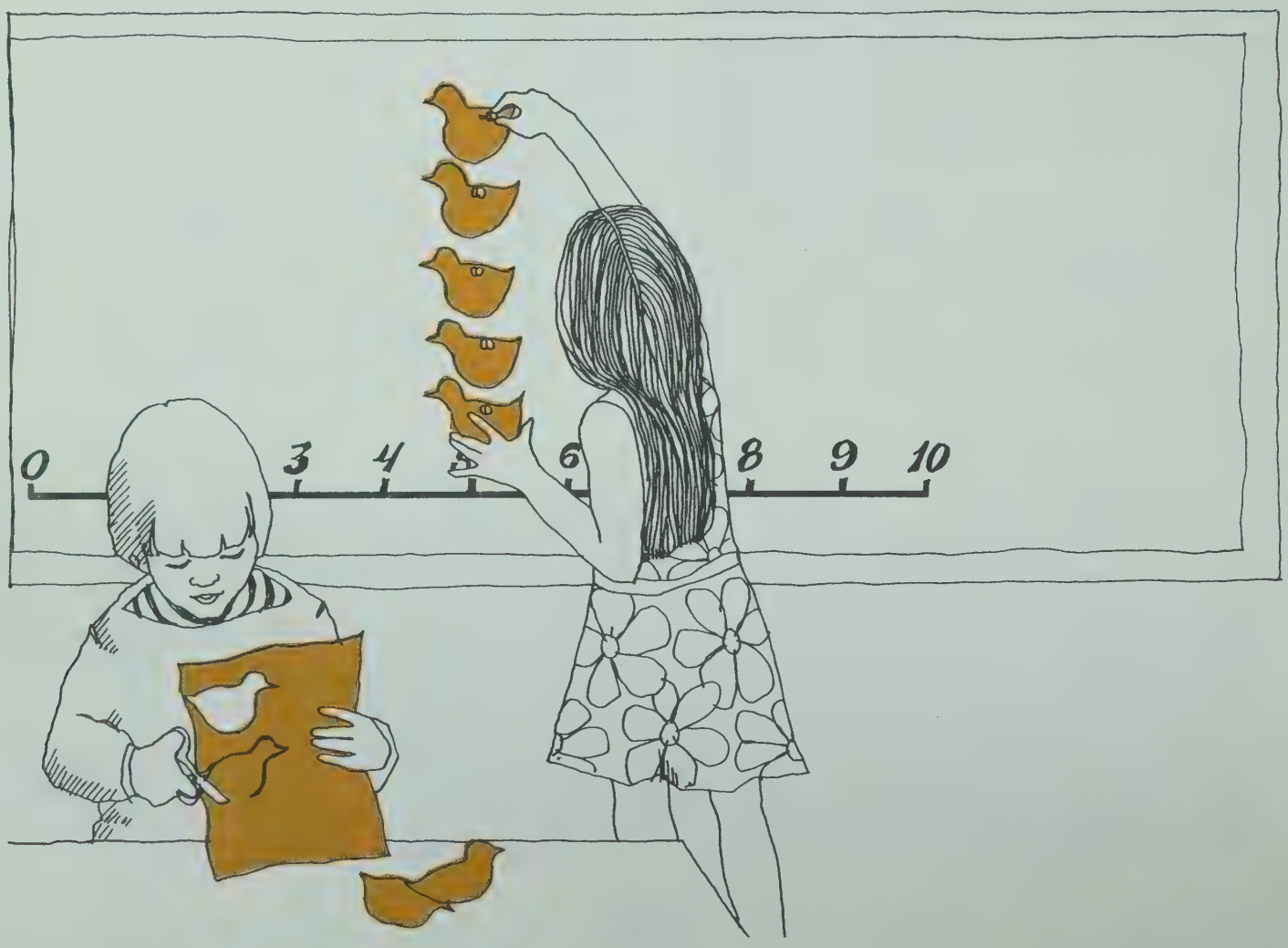


FIGURE 7

APPRAISAL

Give each of nineteen children a numeral card which has one of the numerals $^{-}9$, $^{-}8$, $^{-}7$, $^{-}6$, $^{-}5$, $^{-}4$, $^{-}3$, $^{-}2$, $^{-}1$, *0*, *1*, *2*, *3*, *4*, *5*, *6*, *7*, *8*, and *9* printed on it. With masking tape or chalk, mark on the floor a line having nineteen points, each about 30 centimeters from the next point. Ask the children with the numeral cards $^{-}9$ and *9* to take the end positions on the line. Have the other children take their places as you continue to call the other numerals in a mixed order; for example, you might call $^{-}7$, *8*, *6*, $^{-}5$, $^{-}3$, *4*, *2*, *0*, and so on. If a child takes an incorrect position, ask him to give his card to another child who does not hold a card.

After the nineteen children are located in the correct positions, ask a few of them, by name, to take their seats. Let a child take one of the vacant positions if he can name one of the numerals correctly. As he occupies the vacant position, give him the appropriate numeral card. Repeat this procedure until the vacant positions are filled.

Continue this activity until all the children have had a turn. If interest continues, give each child more than one turn; in particular let those who give an incorrect response have several chances.

Materials

Numeral cards, 19, numbered from $^{-}9$ to *9*, one card for each numeral (*Module 20*)
Masking tape or chalk

COMPETENCY MEASURE

Put the nineteen numeral cards on a table in front of the child. Also make available a line marked with nineteen points; draw it on the chalkboard, on the floor, or on paper.

TASK 1 (Objective 2): Say, Select the numeral cards for *0* and *1*. The child should choose both cards correctly.

TASK 2 (Objective 1): Say, Place the numeral cards for *0* and *1* on the line so that some points of the line are left over for negative numbers. The child should name any two consecutive points *0* and *1*, except that *0* must not be placed at either end of the line.

TASK 3 (Objective 2): Give the $^{-}3$ numeral card to the child and say, Name this numeral. The child should say "negative three."

TASK 4 (Objective 1): Say, Place the $^{-}3$ numeral card where it belongs on the number line. The child should place the card at the third point from *0* and on the opposite side of *0* from *1*. If the child has placed the *0* and *1* cards so that there is no point corresponding to $^{-}3$, move the *0* and *1* cards as necessary before asking the question. If the child uses the $^{-}1$ and $^{-}2$ cards to locate the position for $^{-}3$, that is entirely satisfactory.

Materials

Numeral cards, 19, numbered from $^{-}9$ to *9*, one card for each numeral (*Module 20*)

ABCDEFGH 076543
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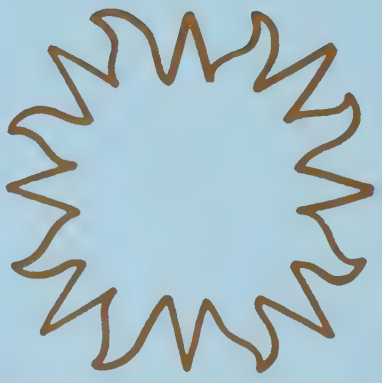
20 Using Numbers/c

SCIENCE...



A PROCESS APPROACH II

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SCIENCE... A PROCESS APPROACH II

MODULE

21

Observing/j

Weather

OBJECTIVES

At the end of this module the child should be able to

1. *CONSTRUCT* a record of weather conditions on a chart, using symbols.
2. *IDENTIFY* weather conditions and *DISTINGUISH* between conditions from one day to another in comparative terms, such as "hotter or warmer than," "cooler than," "windier than," or "cloudier than," using the data recorded on a weather chart.
3. *NAME* the temperature to the nearest 5 degrees using a Celsius thermometer.

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AAAS

SEQUENCE

IDENTIFYING
conditions that produce changes in molds and green plants.
MODULE 28
Observing/k
DEMONSTRATING
how to use a thermometer to measure changes in temperature in degrees Celsius.
MODULE 41
Measuring/h
DISTINGUISHING
between weather conditions from one day to another in comparative terms using data recorded on a weather chart constructed by the child.
THIS MODULE
Observing/j
NAMING
the temperature to the nearest 5° using a Celsius thermometer.
THIS MODULE
Observing/j
DESCRIBING
objects or changes in objects after making observations using several of the senses.
MODULE 18, 19
Observing/h, i
DISTINGUISHING
between the temperatures at different places and at different times using a color-coded thermometer.
MODULE 5
Observing/c
NAMING
points on the number line using the whole numbers -9 to 9.
MODULE 20
Using Numbers/c

Photos on page 7, top to bottom: Union Pacific Railroad; United Nations; National Film Board of Canada; International Harvester Company

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

All children enter school with some knowledge about weather. They see and hear weather reports on television and radio. They are aware that weather controls many of their activities, determining, for example, the clothes they wear and the games they play. Temperature, sky cover (cloudiness), wind, rain, and snow are all observable aspects of weather. As the children engage in the activities of this module, they identify weather conditions and observe a variety of changes in these conditions. The children discover the usefulness of such comparative phrases as "warmer than yesterday morning" or "colder than freezing" in distinguishing between changes in weather from one day to another.

This is the second module in which a thermometer is used in interpreting the weather. In *Temperature, Observing c, Module 5,* the children read a thermometer with a color-coded scale. In the present module the child reads a numerical temperature scale, which allows for more precise measurement. In later modules, the child continues to use the thermometer while exploring the concepts of calibration, expansion, and interpolation.

The temperature of an object is commonly expressed according to one of two scales, the Celsius (C) scale in the metric system or the Fahrenheit (F) scale in the English system. The Celsius scale, formerly called the centigrade scale, is used throughout most of the world. Although the Fahrenheit scale has remained predominant in the United States, it is probable that we will soon convert to the metric system. In this module, as in all of *Science . . . A Process Approach,* the emphasis is upon the metric system of temperature measurement, since it is the one universally used by scientists. Because most adults in the United States are not familiar with the Celsius scale, you may want the children to make charts comparing the Celsius and Fahrenheit scales for their parents (see Figure 1).

Children frequently confuse the terms temperature and heat, and regard the two as synonomous. Do not expect the children to distinguish between the two in this module. In later modules, the difference between temperature and heat will be stressed. If you have not already done so, now would be a good time to read the Science Background Paper "Measuring Temperature and Heat" in the *Commentary for Teachers.*

Most children will already be able to read and record temperatures by using the numerals 0, 10, 20, 30, and so on. If any of the children are not able to do this, you may want to take time to teach them. Depending on the size of the thermometer and the divisions that are marked off, some of the children may be able to make finer distinctions: detecting differences to the nearest 5 degrees or even to the nearest 2 degrees. Still other children may initially use only the color designations described in *Module 5.* With practice, by pairing the color representation with the numerical reading, these children will learn how to read the thermometer numerically.

This module is designed to be continued over a long period of time, perhaps for most of a year. As the children develop new number skills, they can apply these skills to the activities.

Vocabulary

weather	breezy
symbol	windy
Celsius (optional)	rain
Fahrenheit (optional)	fog
clouds	snow
cloudy	smog
overcast	frost
wind	thunderstorm
calm	

(Use terms appropriate to your locale.)

COMPARATIVE SCALE

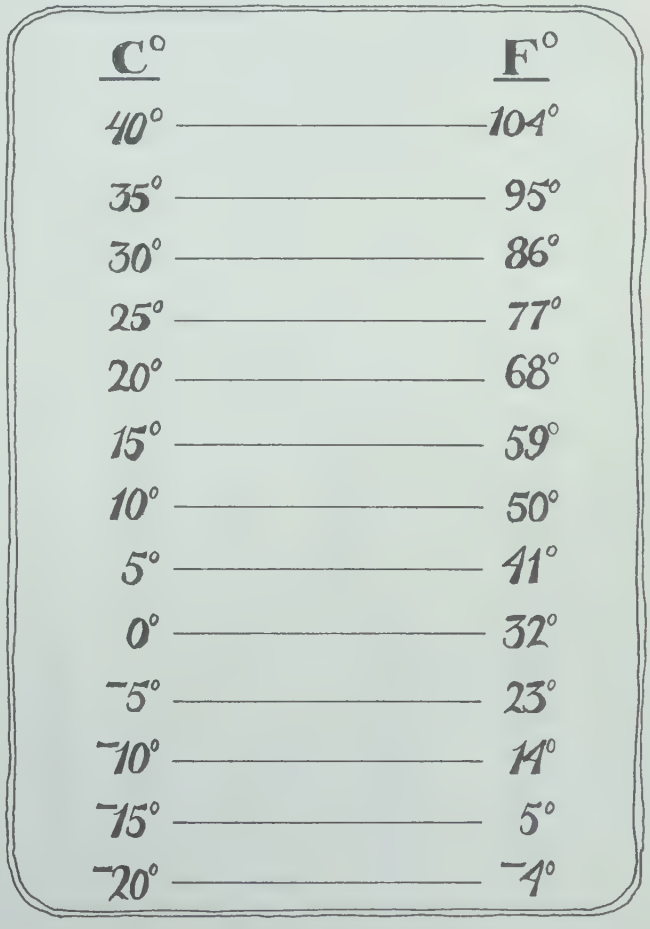

FIGURE 1

INSTRUCTIONAL PROCEDURE

Introduction

Ask the children to describe how weather affects their lives. The discussion will probably begin with personal aspects, such as which clothes to wear, what activities to engage in, and how one feels (for example, warm, chilly, comfortable). You may then be able to extend the discussion to consideration of the relationship between local weather and the local economy: what are favorable conditions for construction work, farming, recreation, and so on.

Discuss with the children the ways in which weather can be described, perhaps agreeing on the four categories—temperature, clouds, wind, and "other weather"—that are emphasized in *Activity 2.* To represent the varieties of conditions in each category, gradually introduce weather symbols. You may wish to display the wall chart *Weather Symbols* (see Figure 4). Use of the symbols is discussed in detail in *Activity 2.*

Materials

Weather Symbols, 1 wall chart, Figure 4 (*Module 21*)
(Note: You may want to color the temperature circles on the chart or paste colored disks over the circles before displaying the chart.)

Activity 1

You may wish to review the activities of *Temperature, Observing c, Module 5,* to reintroduce the thermometer. You may want to use the *Temperature Chart* supplied for the present module. A five-day chart makes it possible to compare temperatures from day to day. (See Figure 2.)

To set up the *Temperature Chart,* place the ribbons through the slits in the cardboard so that the red portion is on the bottom and the white portion on the top. Tie the ribbons loosely at the back. The ribbons can then be pulled up or down to indicate temperature changes throughout the week.

The temperature should be taken outside, in the shade, at the same time each day. At first, you may have to do this, but gradually the children should take over this responsibility. Children who are able to read the numerals on the thermometer scale can record the daily temperatures on the chalkboard or on the *Temperature Chart.* Help other children to learn to read the ribbon scale.

Materials

Thermometer, 1, Celsius, $^{-}20^{\circ}$ to 110° (*Module 21*)
Temperature Charts, 3, Figure 2 (*Module 21*)
(Note: The charts show the Celsius scale because the metric system is used throughout *Science . . . A Process Approach.* If you prefer to use the Fahrenheit scale as well, refer to the comparison of scales shown in Figure 1.)

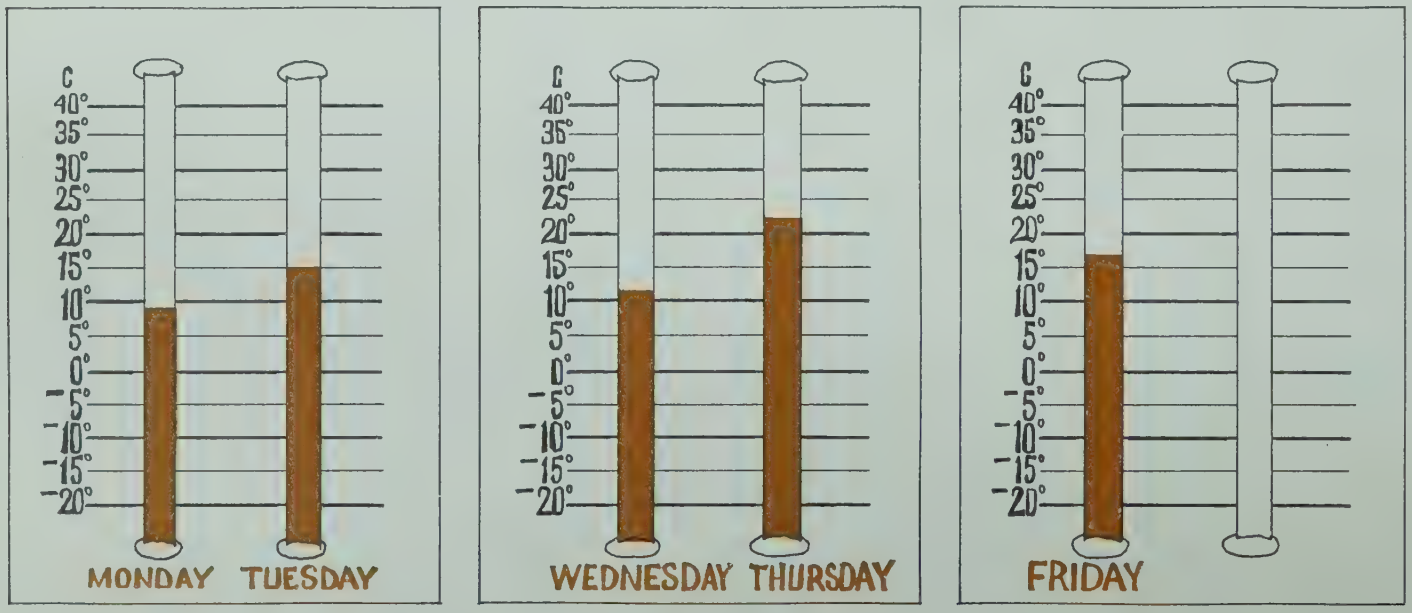

FIGURE 2

Activity 2

Encourage the children to observe weather conditions at the same time each day. Have each child describe the conditions on a copy of the *Weather Chart* by using the symbols briefly encountered in the *Introduction.* The wall chart *Weather Symbols* should be prominently displayed.

You might make a wall chart like the individual weather charts (see Figure 3) or modify this chart to reflect local weather conditions. Each day let a different child be responsible for the entries made on the wall chart. Each child can also keep a daily record on the individual weather charts. You might ask the children to make weather observations at home on Saturday and Sunday, and to record them on the chart when they come to school on Monday. The chart might provide space for observations made over several weeks.

Weather Chart

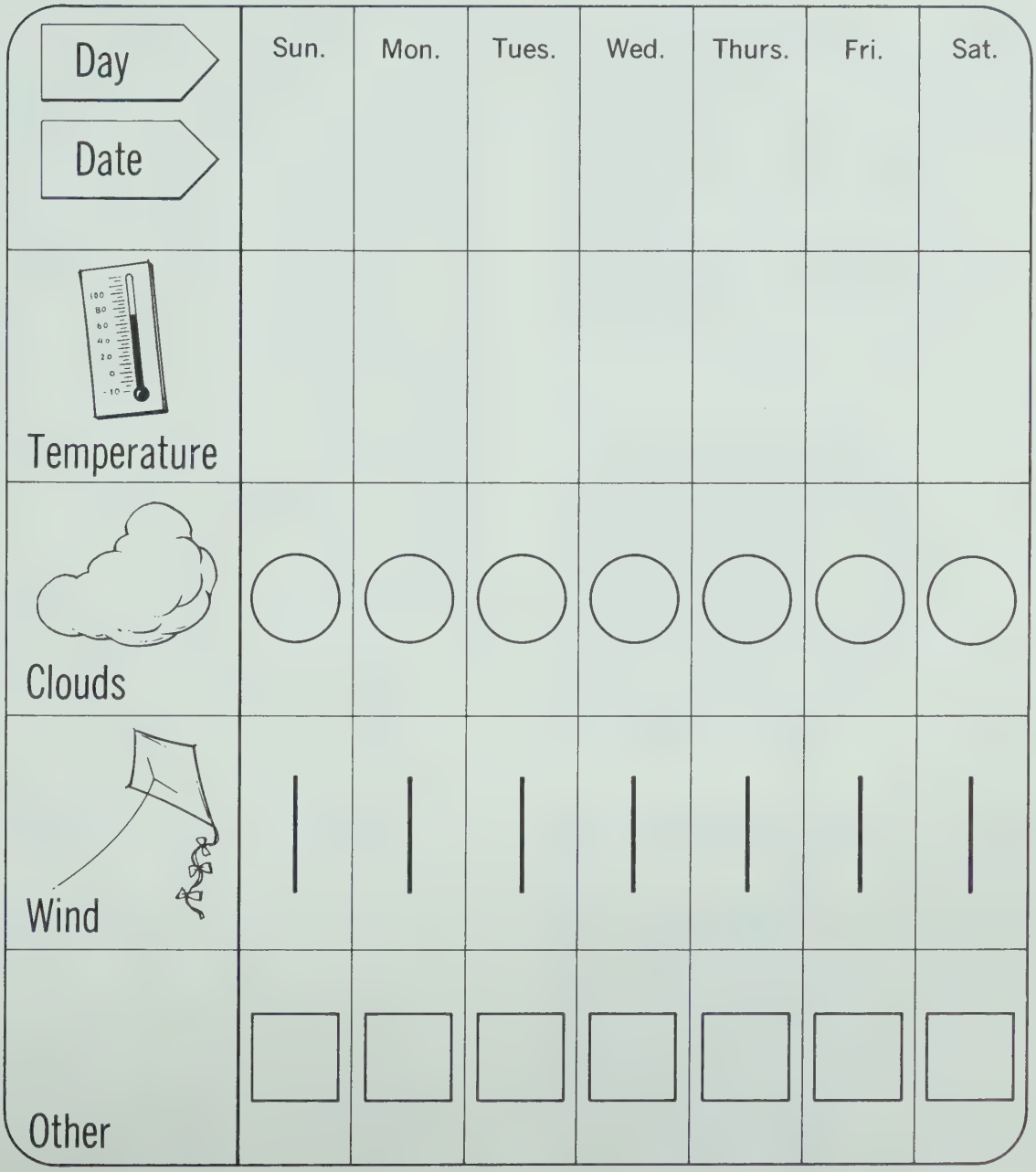

FIGURE 3

Young children need not use the technical vocabulary of the weatherman. The simplified categories and symbols suggested in this module are adequate for a daily record and for frequent, brief discussions. These symbols and categories will lead naturally to later usage of standard weather symbols. The following comments about the weather symbols (see Figure 4) may be useful.

Temperature. The children should record the temperature in degrees Celsius by using a numeral. Although some children may be able to read the temperature to the nearest degree, most will probably need extensive practice to read even to the nearest 5 degrees. You may also want the children to use the color code indicated in Figure 4. Some children may use *only* the colors, at least in the beginning.

In many localities, below-zero (negative) temperatures will be recorded. If negative temperatures never occur in your area, you should at some time during the year discuss below-zero readings with the children. You might also mention that zero on the Celsius scale is the freezing point of water.

Weather Symbols

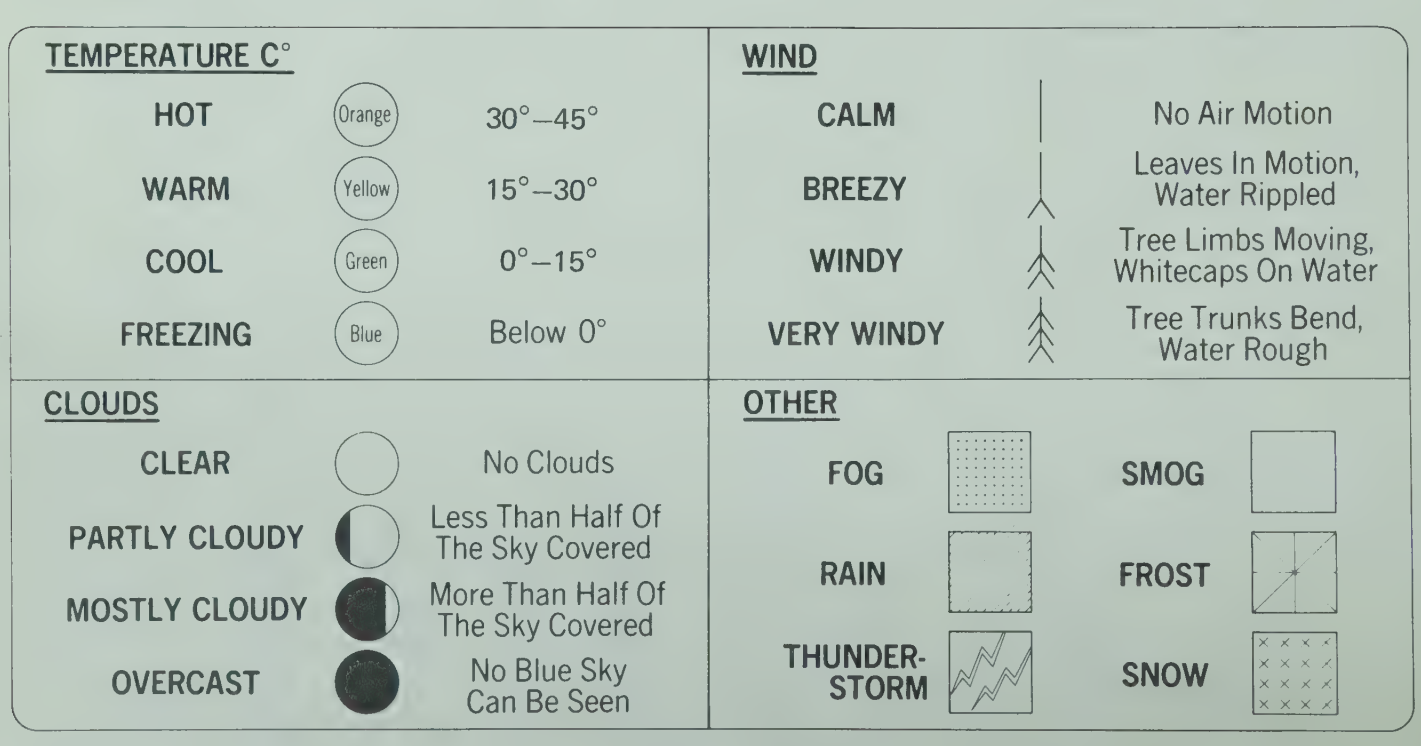

FIGURE 4

Clouds. Classification of cloud type is often difficult and is avoided in this module. Instead, the children observe the amount of cloudiness in the entire sky and indicate this using symbols. No measurement of the amount of cloudiness need be made, only careful estimates are required. The photographs in Figure 5 should help the children classify cloudiness.

Wind. The barbs on the shafts of wind arrows are used to show wind speed. No discussion of wind direction is included in this module. However, if the children introduce the idea of direction, discuss it with them and decide whether to add it to the record.

Other Weather Conditions. Children should use symbols to represent snow, rain, fog, smog, frost, and thunderstorms. The "other weather" symbols in Figure 4 should be used to show conditions as they exist at the time of the observation. Some weather charts, however, have entries that indicate a cumulative condition during a specified period of time preceding the actual observation. Therefore, the children may want to devise their own symbols to indicate relative amounts of precipitation, smog, and so on (for example, heavy, medium, or light) during the 24-hour period since the last entry.

The analysis of the data that the children record on their weather charts is important. Point out frequent combinations of significance: snow and freezing temperatures usually occur together—that is, the temperature usually must fall to about 0°C before snow occurs; rain and overcast skies usually accompany each other; and fog generally occurs only during periods of calm or when breezes are light. Because weather patterns vary from one part of the country to another, you should stress the relationships that are of local importance.

The children might like to make their own booklets to illustrate the weather symbols. For example, each child might make a cloud book, a wind book, and so on, pairing a picture illustrating the weather with the appropriate symbol.

Materials

Weather Chart, 1 spirit master, Figure 3 (*Module 21*)
Weather Symbols, 1 wall chart, Figure 4 (*Module 21*)
Wall chart, 1, same as *Weather Chart* or modified to reflect local weather conditions
Thermometer, 1, Celsius, ⁻20° to 110° (*Module 21*)

FIGURE 5

Activity 3

Prepare 3 sets of three large cans of water as described in *Materials.* Ask the children to put their fingers into each of the three containers of water at one of the stations and to say which is warmer and which is cooler. Emphasize the use of such phrases as "warmer than the first can" and "cooler than the third can." As they compare the water temperatures in the cans, the children should realize that they describe the water in one can as "cooler" or "warmer" depending upon the water they are comparing it with.

Some of the children will probably suggest that a thermometer be used to determine the temperature more precisely. Have one or two children at a time place the cans in order from coolest to warmest and then use a thermometer to find the temperature of each. If temperature conditions are suitable, you might set a container of water outdoors for about an hour. The children can then judge how warm or cool the water feels, and then determine its temperature with a thermometer.

During this activity, the children should begin to associate a rise in the column of alcohol in the thermometer with warmer water, and a fall in the column with cooler water. If the children have difficulty with this concept, let them experiment further with the water and the thermometers. They will eventually associate changes in the thermometer with changes in the environment.

Materials

Cans, 9, large, three cans of water at about body temperature (37°C), three of water at about room temperature (20° to 24°C), and three of water at about 10° below room temperature (10° to 14°C). (Note: Draw hot, lukewarm, and cold water from a faucet. At each of three stations, place a set of 3 cans differing in water temperature. Use thermometers to check the water temperatures.)

Thermometers, 3, Celsius, ⁻20° to 110° (*Module 21*)

Activity 4

Ask the children to observe and record the outside temperature hourly on one or more days. If they do this individually, give each child a copy of the *Hourly Temperature Record* (Figure 6) or a weather chart like Figure 2 with the columns labeled with hours of the day rather than days of the week. If the observation is to be a group activity, a record kept on the chalkboard will suffice. Discuss the results, emphasizing changes and patterns in the day's record.

Materials

Hourly Temperature Record, 1 spirit master, Figure 6 (*Module 21*) or weather charts similar to Figure 2 that you prepare

Thermometer, 1, Celsius, ⁻20° to 110° (*Module 21*)

Hourly Temperature Record

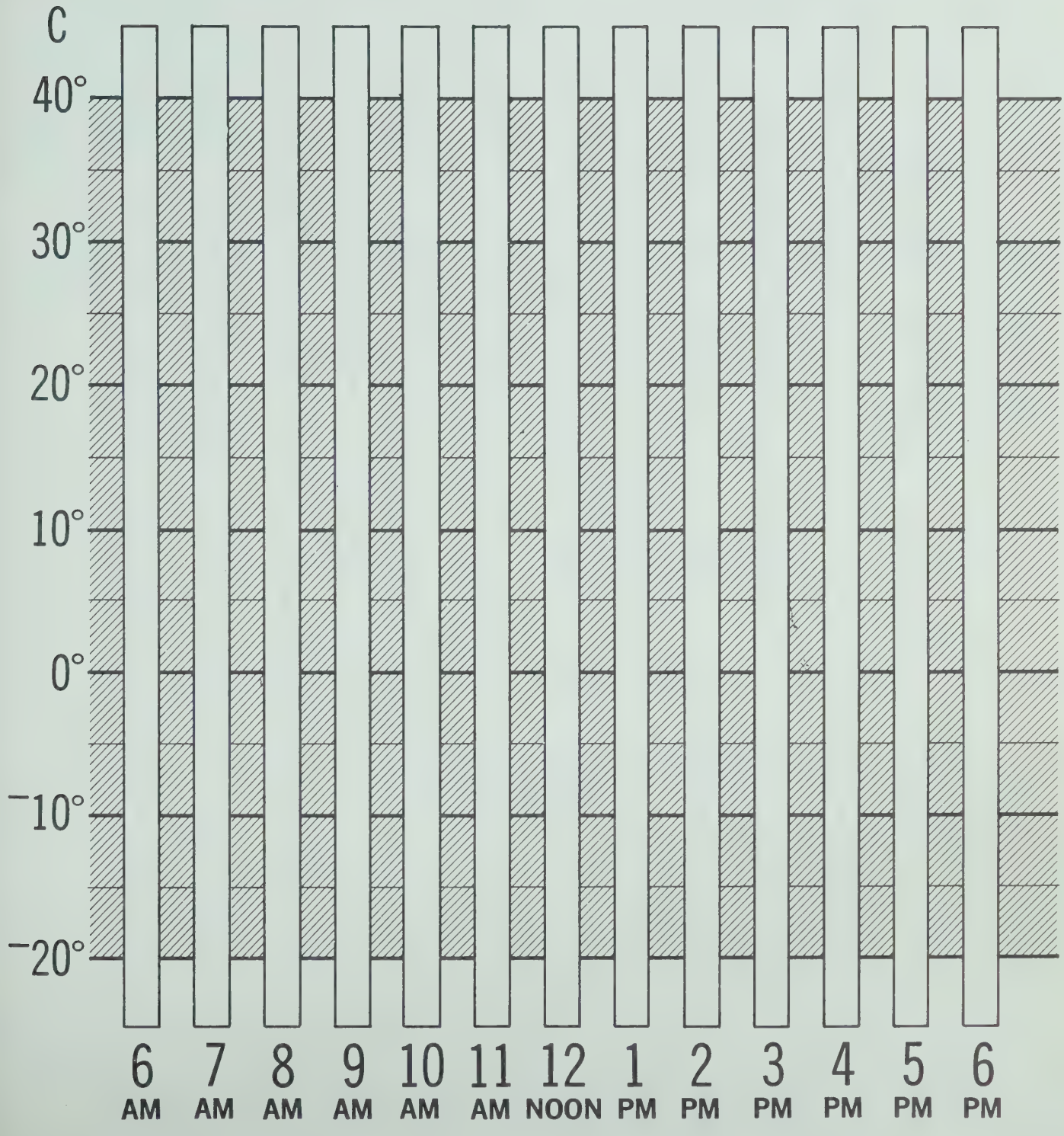

FIGURE 6

Generalizing Experiences

1. Have the children examine the completed wall chart of weather conditions. Discuss the weather recorded for given days and relate to that the children's activities and their clothing on those days. Discuss the weather conditions of several consecutive days.

Ask the children to look at their own weather charts and to count the cloudy days, the days on which temperatures went below 20°C, and the days on which temperatures went above 20°C.

An exchange of charts with a school in another part of the country should prove particularly exciting to the children. This would emphasize the distinct weather patterns that exist in different geographic areas.

2. Choose a day when the weather is very different from that of the day before. Soon after the children are assembled in the morning, ask them to describe the weather conditions that they noticed as they came to school that day. Give the children paper and crayons, and ask them to show what they noticed. They may draw a weather symbol or draw a picture such as a snowflake, a cloud, or an effect of the wind. Have the children show their drawings to the class and explain their ideas.

3. To help them associate weather symbols with actual weather conditions, have the children play a game in which they make up fictitious weather reports. The weather may be reported orally, recorded with symbols, or recorded with symbols and interpreted orally. Encourage the children to recognize inconsistencies in the reports. For example, if a child reports that the weather is clear, very windy, and raining, and the temperature is ⁻10°C, the other children should identify the incompatibilities.

4. You might suggest such home activities as calling a local weather bureau, dialing the weather number for a current weather report or forecast, or watching the weather report on television. You might take the children to a weather station at an airport.

Materials

Wall chart, 1, weather conditions previously entered by children
Weather Charts, 30, previously completed by children (*Module 21*)
Drawing paper, several sheets for each child
Crayons, 1 box for each child

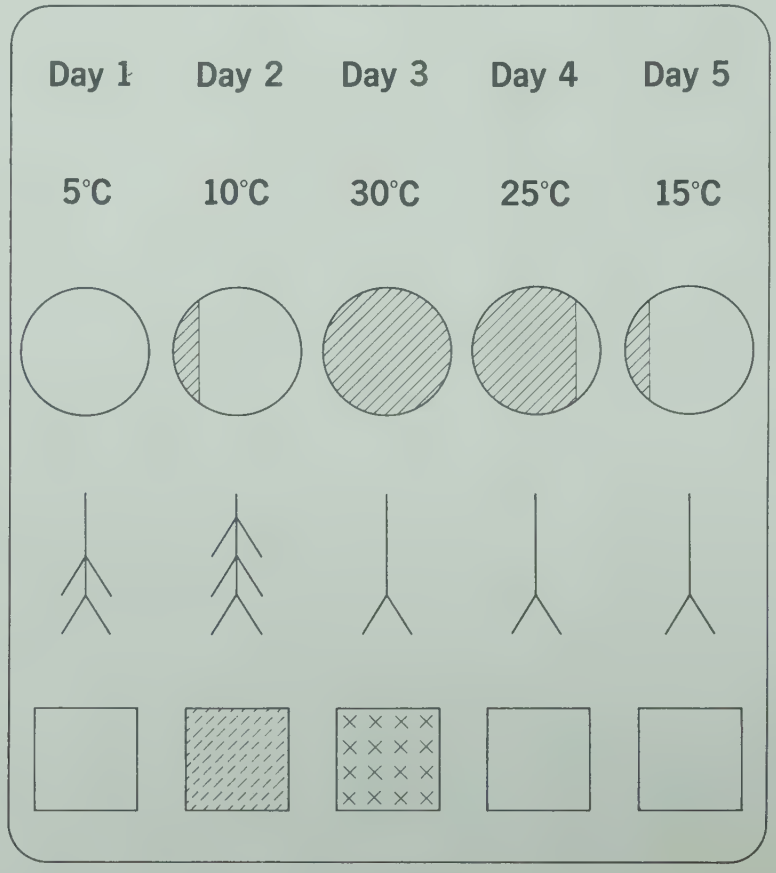

FIGURE 7

APPRAISAL

Give each child a thermometer, a pencil, and a large index card or a piece of paper. Take a short walk outdoors and ask each child to record the outdoor temperature and to make other notes about the weather. After returning to the classroom, have the children use their notes as a basis for recording information on the wall chart and on their individual weather charts. Eventually, the children should make accurate entries without prompting from you or from other children in the class.

Ask several children to compare specific aspects of the day's weather with that recorded for previous days. They should use comparative terms readily.

Materials

Thermometers, 30, Celsius, ⁻20° to 110° (*Module 21*)
Index cards or piece of paper, 1 for each child
Pencils, 1 for each child

COMPETENCY MEASURE

Post the wall chart *Weather Symbols* (Figure 4) near the child.

TASK 1 (Objective 1): Give the child a sheet of paper with a circle drawn on it. Point to the wall chart and say, Here are the symbols that we have used to show different kinds of weather. Make a symbol to show how cloudy it is today. The child should record the cloud-cover correctly.

Give the child the chart *What Was The Weather?* (See Figure 7.)

TASK 2 (Objective 2): Expose only the day designations and the squares, and ask, On which day did it rain? The child should select Day 2.

TASK 3 (Objective 2): Expose only the day designations and the symbols for wind, and ask, On which day did the branches of the trees move most? The child should select Day 2.

TASK 4 (Objective 2): Expose only the day designations and the temperatures. Ask, Which day was warmer than Day 4? The child should select Day 3.

TASK 5 (Objective 2): Expose only the day designations and the cloud symbols, and say, Find a day that was cloudier than Day 2. The child should choose Day 3, Day 4, or both.

TASK 6 (Objective 3): Hand the child a Celsius thermometer. Say, Read the temperature on this thermometer. The child should read the thermometer correctly to the nearest 5 degrees.

Materials

Paper, each sheet with a circle drawn on it, 1 sheet for each child
Crayon, 1, to color in circle
What Was The Weather?, 1 chart, Figure 7 (*Module 21*)
Weather Symbols, 1 chart, Figure 4 (*Module 21*)
Cover sheets, 2, to cover weather symbols in *Tasks 2-5*
Thermometer, 1, Celsius, ⁻20° to 110° (*Module 21*)

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21 Observing/j

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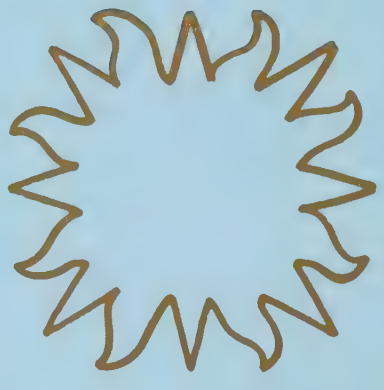

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SCIENCE... A PROCESS APPROACH II

MODULE

22

Communicating/a

The Same but Different

OBJECTIVES

At the end of this module the child should be able to

1. *DESCRIBE* similar characteristics among a group of similar things.
2. *DESCRIBE* different characteristics among a group of similar things.
3. *DISTINGUISH* between a collection of information that is sufficient to identify an object and one that is not.
4. *DESCRIBE* a sufficient number of characteristics of an object to make possible unambiguous identification of the object.

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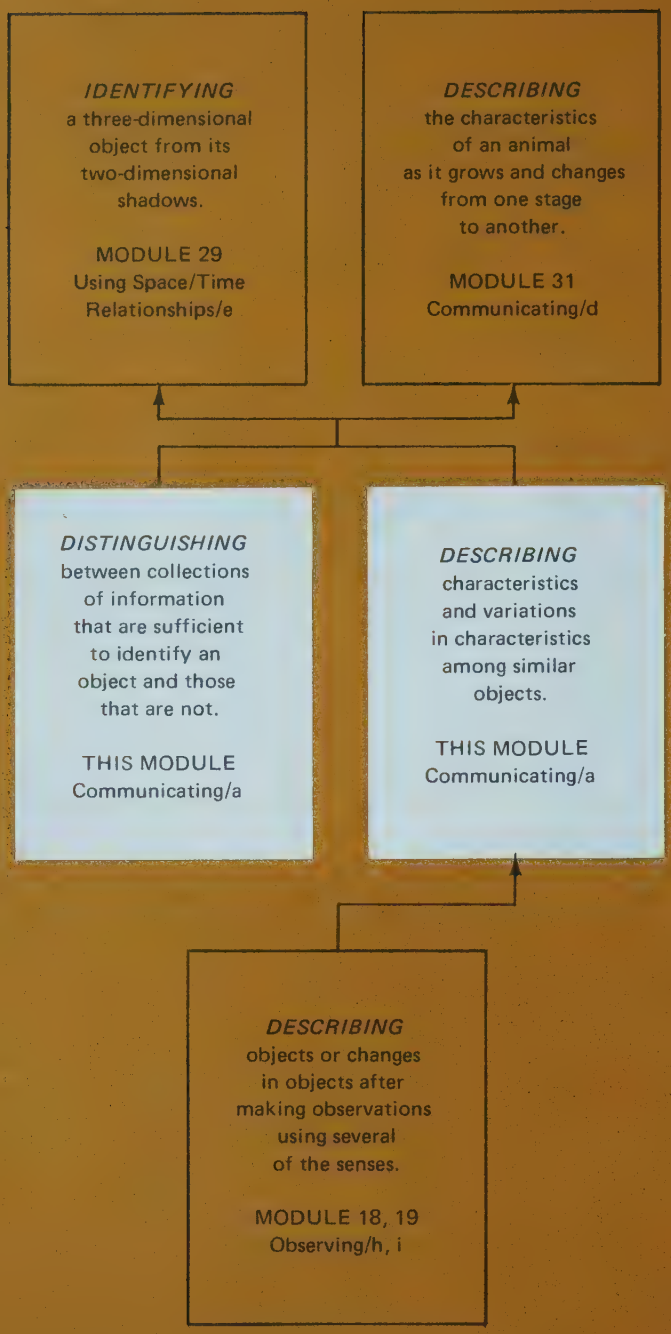
SEQUENCE


IDENTIFYING
a three-dimensional object from its two-dimensional shadows.
MODULE 29
Using Space/Time Relationships/e
DESCRIBING
the characteristics of an animal as it grows and changes from one stage to another.
MODULE 31
Communicating/d
DISTINGUISHING
between collections of information that are sufficient to identify an object and those that are not.
THIS MODULE
Communicating/a
DESCRIBING
characteristics and variations in characteristics among similar objects.
THIS MODULE
Communicating/a
DESCRIBING
objects or changes in objects after making observations using several of the senses.
MODULE 18, 19
Observing/h, i

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

This module extends the experience children have had in observing and communicating about objects and changes in objects. The children learn that objects can be much alike in several characteristics but different in others—that is, that there can be *variations* among objects of the same kind. For example, the children have no difficulty recognizing a dog, although there is great variation among different breeds of dogs or even among individual dogs of the same breed. The children look at several leaves from the same tree and recognize that the leaves are all similar and can be identified as belonging to one kind of tree, yet the children are able to find variations from leaf to leaf. In this way the children practice recognizing and describing differences and similarities among objects of the same kind, and they practice classifying objects on the basis of their similarities.

As the children observe variation among objects, they learn to describe their observations so that accurate information is conveyed. In order to communicate effectively the children may have to describe several properties of objects. The activities of this module give the children experience in using appropriate descriptive terms and in making a suitable selection of properties so that objects can be unambiguously identified. Continued stress on accurate and adequate communication is desirable throughout the study of science.

The skills of this module are important and useful in other parts of the curriculum. During reading activities, the similarity and difference (in both sound and spelling) of such words as *hit, hat, hut,* can be emphasized. In mathematics, number sentences such as $4 + 1 = ?$ and $4 - 1 = ?$ provide helpful opportunities to identify similarities and differences in mathematical statements. In art and music the possibilities are limitless.

Vocabulary

differences	characteristics
similarities	variations

Advance Preparation

A day or two before you teach *Activity 1,* ask each child to bring to school a picture of either a dog or a cat cut from a newspaper or magazine.

INSTRUCTIONAL PROCEDURE

Introduction

Read the children the following story about Marty and his sister Lucy. Explain to the children that Marty is in the sixth grade and Lucy is in kindergarten. Also tell them that the story reveals a type of mistake that is sometimes made.

> One morning Marty's mother said to him, "I would like Lucy to see the flowers in the big greenhouse next to the school. Will you meet her when school is over and take her through the greenhouse? I will meet you at the greenhouse with the car at three-thirty."
>
> "All right," said Marty.
>
> "Oh, good," said Lucy when Marty told her the plans.
>
> "Don't forget, Lucy," said Marty. "Go to the greenhouse right after school and I will meet you there."
>
> As soon as school was over that afternoon, Marty walked to the glass greenhouse next to the school. But Lucy was not there. "Maybe she is inside," he thought, and went in. Lucy was nowhere to be seen. Marty went back outside and waited at the door. Lucy still did not come. "Maybe Lucy forgot about meeting me," thought Marty. Just then his mother drove up. "Mother," he cried, "Lucy isn't here at the greenhouse."
>
> "What do you suppose has happened to her?" Mother asked.
>
> "I don't know," Marty said, "I told her to meet me at the greenhouse right after school."

Interrupt the reading of the story and ask the children if they have any ideas about what happened to Lucy. Show the class a picture of a glass greenhouse and a house painted green. Discuss the children's suggestions briefly. Then continue.

> Then Marty's mother started to laugh. "Look, Marty," she said. "Over there is a house that is painted green. Do you suppose Lucy thought *that* was the greenhouse? After all, both the glass house with the flowers and the house painted green are called green houses."
>
> Marty and his mother walked over to the house painted green, and there was Lucy. "Well, children," said Mother, "We have all learned a lesson today. We have learned about a kind of mistake we sometimes make when giving directions."

Again pause in the reading to ask what the mistake was. (If two objects have the same name, we must be

careful to tell which of the two we mean.) After a brief discussion, read the conclusion of the story.

> "We should have told Lucy to meet you at the glass greenhouse with the flowers in it. Then she would have known where to go. Now let's go and see the flowers," laughed Mother. "From now on, we must be sure to say exactly what we mean when we plan to meet someone."

Review the story and discuss with the children the importance of complete and accurate information, as well as the importance of being a good listener.

Materials

Picture cards, 2, one of a glass greenhouse and one of a house painted green (*Module 22*)

Activity 1

Ask some children to bring pictures of dogs to school, and ask some to bring pictures of cats. The children should clip the pictures from magazines or newspapers. The dogs and cats will vary in such characteristics as color, shape, and hair length. Ask the children to display the pictures of cats on one bulletin board or table and the pictures of dogs on another. Point to several pictures and ask the children how they know whether the picture is that of a dog or a cat.

Point to the pictures of dogs and ask how the dogs are alike. Point to one picture of a dog and ask how the dog is different from the others. Continue this activity with the pictures of cats.

Pair off the children who brought pictures of dogs and have each pair compare two of the dogs. Have those who brought in pictures of cats do the same. Have each group tell you about the similarities and differences.

Materials

Pictures of dogs and cats, brought from home by children

Activity 2

Set up several stations each with three items that are "the same but different." See *Materials* for suggested items: three flowers, three leaves from the same tree, three pictures of animals, three containers of colored water of different intensity (tint), and three shoes of different colors and sizes.

Divide the children into pairs and provide each pair with paper and pencils for use in listing the similarities and differences among the three objects at each station. Have the children circulate among the stations. Allow the groups ample time to observe the objects at each station. Together describe the similarities and differences among the objects.

The more individualized you can make the child's experience with the materials and his communication about what he observes, the more effective the instruction will be.

Some children may be interested in going outside to collect sets of similar objects. Additional stations should be set up to accommodate the children's contributions.

Materials

Flowers, 3, of one kind, such as pansies, petunias, tulips, chrysanthemums, or sweet peas
Leaves, 3, from one tree, such as maple, sycamore, or oak
Pictures, 3, of animals of the same kind, such as goldfish, rabbits, horses, or ducks
Containers, 3, 250-ml, clear plastic (*Module 28*)
Food coloring, 1 container, blue (*Module 17*)
(Note: Make three samples of colored water, each a different intensity. You might use 1 drop for the first container, 4 drops for the second container, and 8 drops for the third container.)
Shoes, 3, of different colors and sizes
Writing paper, 1 sheet for each child
Pencils, 1 for each child

Activity 3

Inform the children that they are going to play a game called "Information, Please." It will teach them to be precise when giving information so that they will not make the same kind of mistake that Marty and Lucy made.

Place a row of eight identical containers of colored water on a table in front of the room. The containers should be filled with water of three different colors (see *Materials*). Place one container with red water between a container with blue water and a container with yellow water. Ask any two children to come to the table. As the children watch, have one child look away while the second child points to one of the containers.

Now have the first child face forward again. Explain that the second child pointed to a container of red liquid. Ask the first child to point to this container, too. If the child points to the correct one, ask how he knew which container it was. The child will probably admit that he didn't know for sure because there were two containers of red liquid. Ask the same question if the child points to the wrong container.

If the child doesn't know which container to choose, suggest that he say, "Information, please." Then give the child such information that will positively identify the container. For example, you might say that the container is between the container of blue liquid and the container of yellow liquid. The child should now point to the correct container confidently. Select two more children to come to the front of the room and repeat the activity. This time, however, give sufficient information so that one child can point with certainty to the container which the other selected. Then ask two more children to come forward. After one child has selected a container while the other has his back turned, ask whether anyone in the class is ready to give precise information so that the first child can know which container was pointed to without having to say, "Information, please."

Continue this activity until several of the children have had a turn and until they freely use the expression "Information, please." Encourage the children to give sufficient information in answer to the request, "Information, please."

You may wish to vary the collection of containers by substituting or adding others of different color, quantities of water, or shape. Encourage the children to play the "Information, Please" game in pairs or in small groups using objects of their choosing.

Materials

Containers, 8, 250-ml, clear plastic (*Module 28*)
Food coloring, 3 containers, one of each color: red, yellow, and blue (*Module 17*)
(Note: Fill two containers with red water, three containers with yellow water, and three containers with blue water.)

Activity 4

Give each child two small white cards. Help each child put his left forefinger first on an inked stamp pad and then on each white card. Write his or her name on the back of each card. Give the child one of the two cards to keep. Display the remaining cards on the bulletin board. Challenge the children to identify their fingerprints displayed on the board by using their own cards.

Materials

Index cards, 60, white (*Module 22*)
Stamp pad, 1

Activity 5 (Optional)

Give each child eight or ten unshelled peanuts. Have the children examine them. Ask them how they are alike. Then ask them to describe ways in which one peanut is different from another. Differences may be in overall size (volume), width, length, shape, smoothness, and color. Explain that these differences among objects of the same kind are known as *variations*. Remind the children of the variations among dogs which they discussed earlier.

Suggest that the children arrange their peanuts in several different ways and describe to other children criteria for their arrangements.

Materials

Peanuts, 240-300, unshelled

Generalizing Experiences

1. Suggest that pairs of children play the following game during their free time or at home. One child arranges an assortment of objects in an array on a flat surface. The number of objects displayed might vary from six to twelve. The other child looks at the collection closely for some limited time period, say 30 seconds. He then closes his eyes or turns his back while the first child makes some changes in the arrangement by removing or turning one of the objects or interchanging two of the objects. Next the second child studies the arrangement to detect the change that has been made. Then the children reverse roles. Point out to the children that, when they are playing this game, they are observing variations in the arrangement of the set of objects.

2. Children in small groups might play the game "Twenty Questions." One child thinks of an object in the room while the other children ask questions about properties of that object until they have sufficient information to identify it.

3. Have the children find the differences between the two picture cards shown in Figure 1. As you talk with the children in small groups, reinforce the idea that what they are doing is observing variations among things of the same kind—variations between two similar pictures. When you think all of the children have discovered most of the variations, call on different children in turn to identify the variations. List these on the chalkboard until all of the variations are identified.

Materials

Objects, 6-12, an assortment
Picture cards, 2, Figure 1 (*Module 22*)

FIGURE 1

FIGURE 2

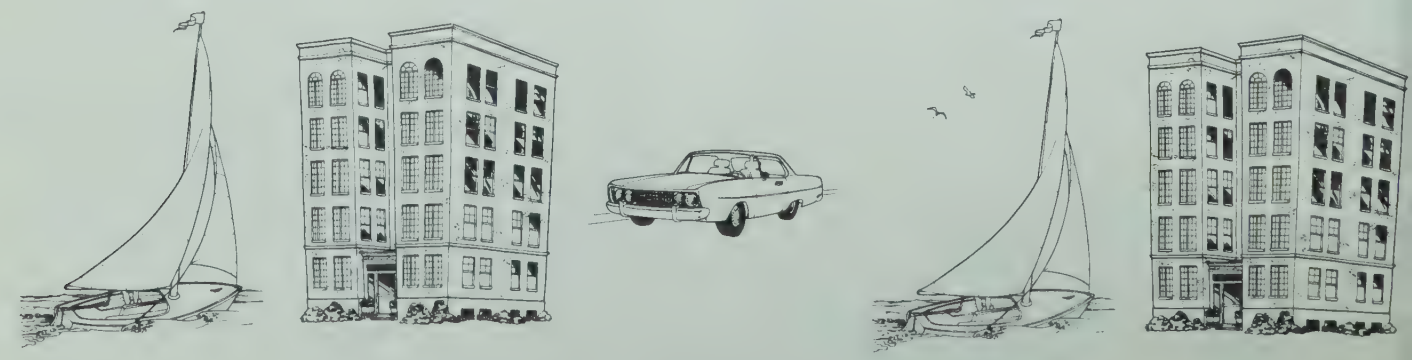

FIGURE 3

APPRAISAL

1. Display the picture cards shown in Figure 2.

Ask the class to point to the picture card with the boat on it. Realizing that they need more information they should say, "Information, please."

Ask the class to point to the boat picture that is next to the car picture. Realizing that they need still more information they should say, "Information, please."

Ask the class to point to the boat picture that is next to a car picture and a house picture. The class should then be able to single out the correct card. Encourage members of the class to ask additional questions about these pictures and to direct these questions to the class as a whole.

2. When you think the class is ready, add the set of picture cards shown in Figure 3 to the ones already displayed. Divide the class into two groups.

Ask one group to secretly choose a card. Have them ask the second group to point to the chosen card. The second group should ask for information about the card until they have picked it out correctly.

Reverse the procedure by asking the second group to pick a card.

Materials

Picture cards, 10, Figures 2 and 3 (*Module 22*)

COMPETENCY MEASURE

Place a penny, a nickel, and a dime, all heads up, on the table in front of the child.

TASK 1 (Objective 1): Say, **Tell me one way in which all of these are alike.** The child should correctly describe one similarity, by making statements such as: they are all coins, they are all round, or they are all "heads up."

TASK 2 (Objective 2): Say, **Tell me one way in which they are different.** The child should correctly describe one difference, by making statements such as: they are all different sizes, or the faces on them are all different. If the child says that two coins are one color and the third is a different color, say, **Tell me one other way in which they are different.**

Put on a table in front of the child 4 pennies, 3 nickels, and 2 dimes in a row like that shown in Figure 4.

TASK 3 (Objective 3): Say, **I want you to point to one of the coins. I will tell you which one it is. Tell me if you need more information. Point to the nickel that is between a dime and a penny.** The child should ask for more information. Then say, **Point to the nickel that is between a dime and a penny. The penny is at the end of the row.** For an acceptable answer, the child should point to the nickel nearest the end of the row. If the child does not initially ask for more information and points to the wrong nickel, ask, **Are you sure?** If he or she is sure, the answer should not be considered acceptable.

TASK 4 (Objective 4): Say, **Now you tell me about one of the coins so that I will be able to point to it.** The child should describe a coin so that you can identify it. If enough information is not given say, **I need to know more about it,** or **I need more information.**

Materials

Pennies, 4
Nickels, 3
Dimes, 2

FIGURE 4

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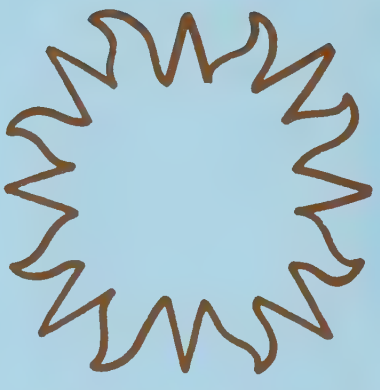
22 Communicating/a

SCIENCE...



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SCIENCE... A PROCESS APPROACH II

MODULE
23

Measuring/b

Comparing Volumes

OBJECTIVES

At the end of this module the child should be able to

1. *DEMONSTRATE* a way to compare two volumes.
2. *IDENTIFY* which of two containers has the larger volume.
3. *DEMONSTRATE* a way to compare the volumes of two containers by reference to a third container or object.
4. *DEMONSTRATE* a way to measure the volume of a container using a supplied standard of reference.

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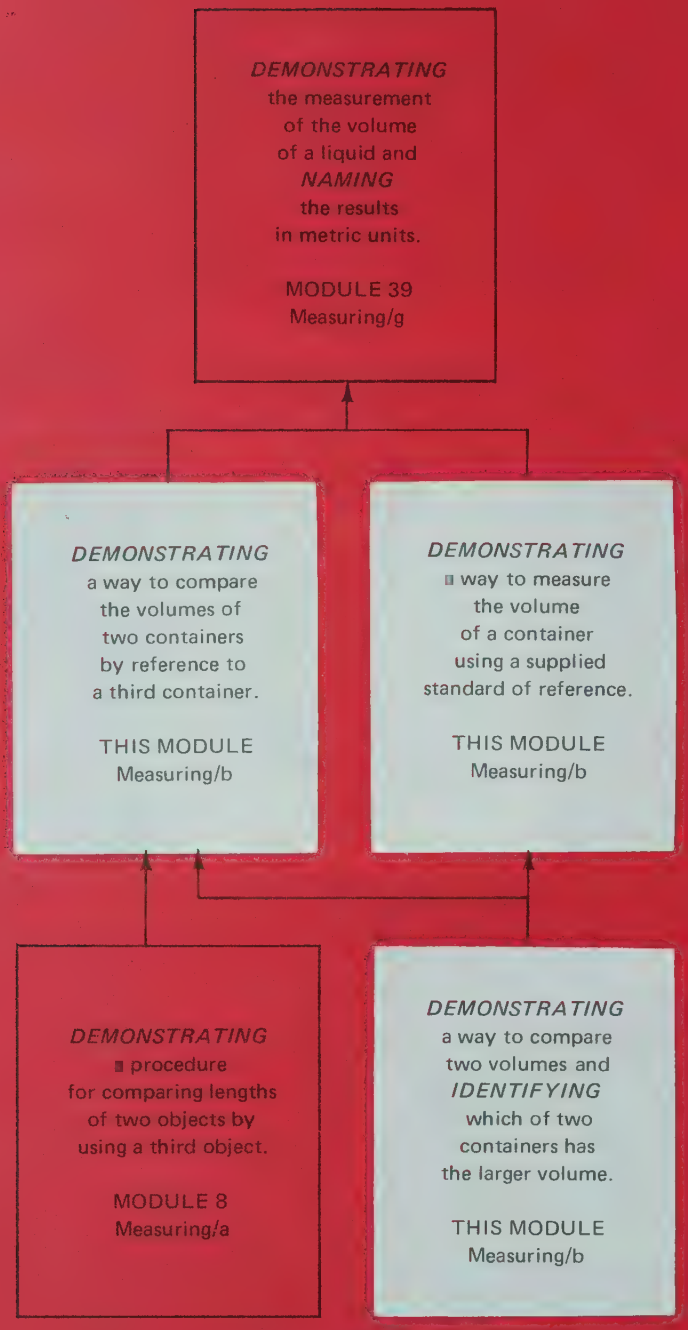
DEMONSTRATING the measurement of the volume of a liquid and *NAMING* the results in metric units.
MODULE 39 Measuring/g
DEMONSTRATING a way to compare the volumes of two containers by reference to a third container.
THIS MODULE Measuring/b
DEMONSTRATING a way to measure the volume of a container using a supplied standard of reference.
THIS MODULE Measuring/b
DEMONSTRATING a procedure for comparing lengths of two objects by using a third object.
MODULE 8 Measuring/a
DEMONSTRATING a way to compare two volumes and *IDENTIFYING* which of two containers has the larger volume.
THIS MODULE Measuring/b

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

In *Length, Measuring a, Module 8,* the children acquire competency in comparing lengths of objects and ordering the objects according to length. In later modules, the children acquire skill in using both arbitrary and metric units for measuring length. The activities in this module introduce the children to the topic of volume. Relate the experiences in this module to those the children have had in measuring length. If the opportunity arises, you may wish to introduce the concept of area; children might investigate the topic of area by means of activities analogous to those presented here for volume.

The children use various methods to compare and to order volumes. They learn to measure the volume of a container by using another object as a standard for comparison. The ability to compare and to order volumes is a useful skill, and worthy of development for its own sake.

Generalizations about volumes that seem obvious to most adults are often not obvious to children. For example, if a round ball of clay is rolled out into an elongated form, many children will say the elongated form has more clay than the original ball. If equal amounts of liquid are poured into containers of different shapes, many children will think that a tall, narrow container holds more liquid than a short wide one. Making actual comparisons of volumes may help to reduce this kind of error of judgment. When the children have an opportunity to measure actual volumes in some way, they should begin to understand the concept of conservation of volume. For example, the volume of a liquid remains unchanged when it is transferred to a container of a different size or shape.

Vocabulary

approximate	order
compare	volume

INSTRUCTIONAL PROCEDURE

Introduction

Put four different clear plastic or glass jars (see *Materials*) on a table where all the children can see them. Fill each of the jars to the top with water tinted with food coloring. Ask the children which jar they think has the most (greatest amount of) water in it. The children's responses may indicate that some of them confuse "most" with "highest" or "tallest."

Tell the children that the amount of liquid a container holds is a measure of the *volume* of the container. Point out that the volume of the container does not change: the same container always holds the same amount of liquid. Then discuss whether the volume of a liquid changes when it is poured from one container into another. You might ask the following question: If you pour a whole carton of milk into a tall, thin glass, do you have more milk than if you pour it into a short, fat glass? The children should explain that there would be the same amount of milk in both cases.

Then return to the discussion of the water-filled jars on the table. Remove all except the narrowest and widest jars. Also place two larger containers, identical to each other in size and shape, on the table. Then tell the children that you would like to have them find a way to find out which of the two water-filled jars holds more water (has the larger volume). They can use only the equipment on the table. Some child may suggest lifting the two containers to see which is heavier; if so, have him try this method. He will probably find that they feel about the same, but if he thinks he feels a difference, point out that since he does not know for sure how much the containers themselves weigh, this evidence is not very reliable. Ask the children for other suggestions.

Collect their ideas and have individual children demonstrate those that seem reasonable. If no child can think of a good method to determine which of the two jars has the greater volume, describe one or more of the following methods, and ask the children if one of these methods might work. Have two or three children try one or more methods, while the whole group watches.

1. Pour the water out of one of the labeled jars, and then pour the water from the second one into the first. If it all goes in with some space left over, the first jar is larger than the second; if all the water will not go in, the second has the larger volume.

2. Pour the water from one of the labeled jars into one of the two identical large containers. Then pour the water from the other labeled jar into the second large container. Then compare the water levels in the two identical containers. If the level of water is higher in one container than in the other, the volume of the jar that originally held this water is the larger of the two.

Ask any child who suggests this method how he can prove that the two identical containers do indeed have equal volumes. The child should fill one with water and pour the water from that container into the other. The water from the first container should exactly fill the second container, unless some was spilled. Help the child pour the water, if necessary.

3. Pour the water from one of the labeled jars into one of the two identical containers, and mark the level of the colored water on the side of the jar; pour the water back to refill the first labeled jar. Now pour the water from the second labeled jar into the large marked container, and compare the level of the liquid with the mark previously made.

After the children have completed this activity, ask them, "Are you now sure which of these two jars holds more water?" If there is a difference in the jars' volumes, the children should have detected it, and should answer "yes." Then ask, "Which of the two jars has the greater volume?" The children should answer that the jar holding the greater amount of water has the greater volume. Then place all four of the original labeled jars on the table and ask, "Can you now tell for sure which of these jars holds the most water?" The children should realize that they cannot determine this without making further comparisons.

Tell the children that you are going to pour a different amount of water into each labeled jar, and that this time they are going to compare the volumes of water in the jars, rather than the volumes of the jars themselves. Pour a different volume of colored water into each of the four labeled jars. With a felt pen, mark the height of the water in each jar.

Put the jars on a table so that all the children can see them. Then ask for three or four volunteers to come to the table. Ask one of them to arrange the jars in order from the jar with the least water to the jar with the most water. Remind the children that the jars are not now filled completely. Record the child's chosen order on the chalkboard.

Ask the other volunteers to arrange the jars and record the order on the chalkboard. Ask the rest of the class if anyone has a different idea as to how the jars should be ordered. If there are other suggestions, record these on the chalkboard, too. Review with the class the variety of arrangements suggested.

If interest continues, let groups of children use different methods to compare the volumes of water in the jars. Do not insist, however, that all children agree on the order of volumes.

Materials

Jars, 4, clear plastic or glass, about 250-ml, labeled with letters *A*, *B*, *C*, and *D*
(Note: These jars should vary widely in shape—tall and narrow, short and wide—but they should not differ too greatly in volume.)
Masking tape, 1 roll, for labeling jars
Felt-marking pen, 1, for labeling jars
Food coloring, 3 containers, one of each color: red, yellow, and blue (*Module 17*)
(Note: Mix any two of these three colors to obtain a fourth color.)
Containers, 2, clear plastic or glass, identical in size and shape, about 500-ml, such as two identical mayonnaise jars.

Activity 1

On a table put 15 alphabetically labeled drinking glasses of different sizes, several 30-milliliter containers, and a supply of sand or water sufficient to fill all of the drinking glasses. Ask for suggestions about how the sizes of the drinking glasses might be compared. The children should work in pairs.

DRINKING GLASS	VOLUME (*number of small containers*)
A	
B	
C	
D	
E	
F	

FIGURE 1

If the children do not suggest it, call their attention to the possibility of filling the small containers with sand or water and then counting how many full containers it takes to fill each drinking glass. Tell the children that this is a way of measuring the volume of a drinking glass. Remind them that volume is a word that means "how much something holds."

Using the method described above, measure the volume of one drinking glass as a demonstration. The volume of the drinking glass will probably not be exactly equal to a whole number of the smaller containers; you will probably reach a point where there is some space left in the drinking glass, but another whole container of sand or water will not fit in. If this happens, record the number of containers already in the glass as the value of the volume of the glass, and instruct the children to do the same when making their own volume measurements.

Leave the drinking glasses, small containers, and sand or water on the table, and have each team of children measure the volumes of several drinking glasses. The children should record their findings in a table similar to Figure 1.

Next, give groups of three to five children each a set of the four geometric containers shown in Figure 2. Ask the children to compare the volumes of the cone and cylinder, and then to compare the volumes of the pyramid and cube. Suggest that the children use sand or water to make the comparisons. To measure the volume of each pair of containers, the children might fill the smaller container of each pair with sand or water, and count the number of small containers needed to fill the larger one. Alternatively, the children might measure each geometric container by using one of the 30-milliliter containers with which they measured the drinking glasses, and then compare the volumes for the two containers in each pair. In each pair of containers, the ratio of the volume of the smaller geometric container (cone, pyramid) to that of the larger one (cylinder, cube) is 1 to 3; however, do not tell the children this ratio, or expect them to obtain it exactly.

Materials

Drinking glasses, 15, of different sizes, labeled with the letters *A* through *O*
Masking tape, 1 roll
Felt-marking pen, for labeling the drinking glasses
Containers, several, 30-ml (*Module 18*)
Sand or water, sufficient quantity to fill the drinking glasses
Paper, 1 sheet for each child to record data
Geometric containers, plastic, 6 of each shape: cones, cylinders, pyramids, cubes (*Module 23*)

FIGURE 2

Activity 2

Ask each child to bring a rectangular box from home, and to write his name on the box. Tell the children that they are going to play a game to find the largest box in the room. Divide the children into groups of four or five and ask each group to select its largest box. When all of the groups are ready, let someone from each group bring its largest box to the front of the room, and have the whole group of children decide which of those boxes is the largest. There may be disagreement about what is meant by "largest" (greatest height, greatest volume, and so on), but do not try to obtain agreement at this time. If the children continue to be interested, they might play the game again, this time to find the smallest box in the room.

Next, put all the boxes together in the middle of the room. Ask the children, "Can the boxes be arranged in order from the smallest to the largest?" "How many different ways can you think of to do it?" Let those who suggest plans demonstrate them. The boxes might be arranged according to volume, or according to a linear dimension—length, width, or height. Carry out one plan to a conclusion; then return the boxes to the middle of the room and try another way. Try to get all of the children involved in the action.

In the course of ordering the boxes, the children will probably discover that some are about the same size. Let groups of children work with those boxes to see if they can determine any small differences in size. Have the groups report their findings to the class as a whole. If any children have new suggestions about how the boxes might be compared, let them demonstrate their methods.

Materials

Rectangular boxes, of many different sizes, 1 brought from home by each of the children
(Note: Suggest small cartons, shoe boxes, cereal boxes, and stationery boxes, for example.)

Activity 3

Put two fairly large boxes of similar size in different places in the room. Ask the children how they could find out, without moving either box, which of the boxes has the larger volume. Let those who have suggestions demonstrate them. If the idea of using a third box as a standard does not develop, suggest it yourself. A question such as the following might help: If you used a third box, could you then compare the sizes of the two boxes? Some child will probably suggest choosing a small box that will fit inside each of the two boxes being compared, and then seeing how many times the smaller box will fit in each of the larger boxes. This procedure is analogous to comparing the length of two long sticks by seeing how many identical short sticks, placed end-to-end, will fit alongside each long stick. If the children have several small boxes of exactly the same size, such as shoe boxes or cereal boxes, they will be able to compare the volumes of the two larger boxes more easily and more accurately.

Have several groups of children use this procedure to compare the volumes of the two boxes. Discuss the children's conclusions; if there is disagreement about which box is bigger, encourage the children to compare the volumes again, possibly using a different small box as a standard unit of volume. Since the measuring technique is not very precise, do not expect children's results to be especially accurate, or even expect all children to agree on which box has the larger volume; the important thing is that the children acquire more experience in measuring volumes by comparison to some standard volume.

If enough time remains, individual children might each be given two boxes and asked to compare the volumes.

Materials

Rectangular boxes, 2, very large, about the same size
Rectangular boxes, from previous activity

Generalizing Experiences

Whenever appropriate opportunities occur, ask children to compare and to measure volumes of familiar objects. Point to two different objects and ask which has the greater volume. Children can make some comparisons by placing objects side by side, others by putting one object inside the other. Sometimes, if appropriate, they might use sand or water to aid in measuring volumes of hollow objects.

Objects in the classroom that the children might compare or measure include sea shells, aquariums, waste-baskets, toy trucks, flower pots, nesting blocks, pencil boxes, and equal-arm balance pans.

APPRAISAL

Divide the children into groups of three or four and give each group two wide-mouthed plastic containers (one 30-milliliter and the other 50-milliliters), two teaspoons, and a container with approximately 100 milliliters of water. Have the children place these items on lunch trays or on several thicknesses of newspaper. Ask the groups to tell which is the larger container, first by looking at it, and then by measuring the volume of each container using the teaspoon and water.

Materials

Containers, 10, 30-ml (*Module 18*)
Containers, 10, approximately 50-ml, such as the deep plastic covers of aerosol cans
Containers, 10, 120-ml, to hold water (*Module 17*)
Teaspoons, 20
Trays, 10, or newspapers

COMPETENCY MEASURE

TASK 1 (Objective 2): Give the child two geometric containers: the cone and the pyramid used in *Activity 1*. Ask, **Which one of these has the larger volume?** The child should choose the pyramid.

TASK 2 (Objective 1): Then say to the child, **Show me how you decided on that answer.** The child should either hold the shapes side-by-side or put one inside the other. If the child answers verbally, ask him again to show how he decided.

TASK 3 (Objective 3): Place two open rectangular boxes, of approximately the same size, in separate parts of the room; place a third, smaller box on your desk. Hand the small box to the child and after pointing out the other two boxes, say, **Find the largest box. You may move only the box given you.** The child should compare each of the larger boxes with the small box, and make his decision based on these comparisons.

TASK 4 (Objective 4): Hand the child a collection of 1-centimeter cubes. Say to the child, **Show me how to measure the volume of one of the boxes you were just using.** The child should start to fill the hollow box with the cubes. Do not expect him to complete the task.

Materials

Geometric containers, 2, plastic, 1 cone and 1 pyramid (*Module 23*)
Rectangular boxes, 3, one very small and two others larger but different from each other in size
Cubes, 100, 1-cm (*Module 30*)

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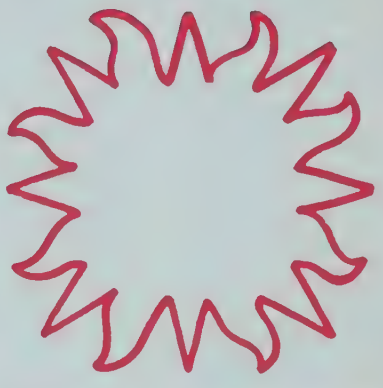

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MODULE
24

Measuring/c

Metric Lengths

OBJECTIVES

At the end of this module the child should be able to

1. *DEMONSTRATE* a way to measure length using a designated standard.
2. *NAME* various units of length in the metric system.
3. *IDENTIFY* an appropriate standard for measuring various lengths.
4. *DEMONSTRATE* a way to measure length using an appropriate standard.

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SEQUENCE

DEMONSTRATING a procedure for measuring and recording changes in the position of an object.
MODULE 27 Communicating/c
DEMONSTRATING how to find rate of change when the rate is measured in units of weight or distance or volume and time.
MODULE 51 Using Space/Time Relationships/h
CONSTRUCTING estimations of linear dimensions of common objects in metric units.
MODULE 34 Measuring/e
IDENTIFYING an appropriate standard for measuring various lengths.
THIS MODULE Measuring/c
DEMONSTRATING a way to measure length using an appropriate standard.
THIS MODULE Measuring/c
DEMONSTRATING a procedure for comparing the lengths of two objects by using a third object.
MODULE 8 Measuring/a
NAMING points on the number line using the whole numbers -9 to 9.
MODULE 20 Using Numbers/c

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

In *Measuring Length, Measuring a, Module 8*, the children made direct comparisons of length. For example, they found that one stick was the same length as another one. In this module the children make measurements of length, first using arbitrary units and then using standard metric units. Other modules extend the use of standard units to the measurement of volume, force, and mass.

The metric units of linear measure (meter, decimeter, and centimeter) are introduced in this module because scientists have universally adopted the metric system for their measurements. In addition, most countries of the world use the metric system for commercial measurements, and it seems probable that within ten years the metric system will be in common use throughout the United States.

Units of length in the metric system are related to each other by powers of ten as follows:

10 centimeters	=	1 decimeter
10 decimeters	=	1 meter
1 meter	=	100 centimeters
1 centimeter	=	0.01 meter
1 decimeter	=	0.1 meter

Consequently, conversions from one unit to another can be made easily by multiplying or dividing by 10. The background paper entitled "The Metric System" in the *Commentary for Teachers* discusses the system more extensively.

An objective of this module is to teach the children to select a metric unit of appropriate size for making a linear measurement. Although there is no absolute rule, a convenient guide is to select a unit that can be laid two or more times along the length being measured.

The children will require considerable practice in measuring with metric units before they feel comfortable using them. For this reason, urge the children to use metric measures whenever possible in and out of school.

Help the children realize that no measurement is exact and that estimation to some fractional part of the measuring unit is necessary no matter how carefully the measurement is made. In this module, when a measurement is not a whole number of units, the children should state a measurement of length by saying, for example, that the length is between 6 and 7 units, or a little more than 6 units, or less than 7 units; or, for example, that one length is about 2 units shorter than another length. If in their mathematics program the children are learning the inequality symbols $>$ (greater than) and $<$ (less than), you might suggest that they use these symbols when they write measurements that are not whole numbers. For example, a measurement that is a little more than 6 units might be written "$>$ 6 units."

Vocabulary

measure	metric
measuring stick	decimeter
unit	centimeter
meter	vertical (optional)
	horizontal (optional)

INSTRUCTIONAL PROCEDURE

Introduction

Place the following articles on a table where all the children will have access to them: many unmarked measuring sticks of various sizes, a ball of string, a roll of adding machine tape, an assortment of shoe boxes, one hundred 1-centimeter cubes, a roll of masking tape, several pencils, and anything else that you think children might find useful in this activity.

Put a large cardboard box on one side of the room and a table on the other side. The box should be nearly the same height as the table. Ask the children if the box will fit under the table. Have them commit themselves and then ask them how they might prove their answers. Someone will probably suggest that the box be moved next to the table for comparison. Have the children pretend that the box is full of rocks and not very easily moved. Ask the children if there are other ways of comparing the heights of the box and table. Call their attention to the articles on the table and suggest that these articles might be used. Have the children demonstrate their suggestions.

One child might hold his hand at his side where the top of the box touches him, and then walk over to the table to compare its height against the height of his hand. Another child might hold a tall stick against both box and table, in turn, and mark each height on the stick. After various methods have been demonstrated, slide the box over to the table and compare the heights directly. Ask the children if their measurements led to a correct prediction about whether the box would fit under the table.

Materials

Measuring sticks, unmarked, six of each length: 5-cm, 10-cm, 15-cm, 30-cm, 50-cm, 75-cm, and 100-cm (*Module 24*)
String, 1 ball
Adding-machine paper, 1 roll (*Module 24*)
Shoe boxes, several
Cubes, 100, 1-cm, (*Module 30*)
Masking tape, 1 roll
Pencils, several
Cardboard box, 1, nearly the same height as the table

Activity 1

Ask the class how high they think the cardboard box is. The children may answer: "As high as John's belt," "Almost as high as the table," or "As high as that stick."

Divide the class into groups of three or four children. Give each child in one group a 5-centimeter measuring stick, each child in another group a 10-centimeter measuring stick, and so on with the 15-, 30-, 50-, 75-, and 100-centimeter measuring sticks. As you distribute the sticks, discuss briefly with the class how to measure the height of the box. The children may not realize that they must measure the height of the box along a vertical, straight line rather than along a crooked or diagonal line. If necessary, show the children that the sticks should be laid end-to-end to measure the height of the box. Have the groups take turns making their measurements.

The children may find that they cannot report the height of the box as a whole number of stick-lengths. Have the children decide how they want to report their results. They might decide to report their results as the *maximum* whole number of stick-lengths, such as 7 stick-lengths, which fit along the edge of the box. Or the children might report that the measurement is between 6 and 7 stick-lengths or more than 6 but less than 7 stick-lengths. Regardless of what they decide, the children will become aware that all measurements require approximation. This is always true no matter how carefully a measurement is made. Have each group reach an agreement on the measurement of the height of the box and report the measurement to you. Record the measurements on the chalkboard.

Materials

Cardboard box, 1, large (see *Introduction, Materials*)
Measuring sticks, 42, unmarked, six of each length: 5-cm, 10-cm, 15-cm, 30-cm, 50-cm, 75-cm, and 100-cm (*Module 24*)

Activity 2

Review with the class the measurements they made in *Activity 1.* Ask why the results were not all the same. In the discussion that follows, the children should realize that each group is measuring the box with a stick of a different length. Ask which group found the right answer. The children should realize that all the answers are correct, provided the measuring has been done carefully, because the box has remained the same size. The children should conclude that when reporting lengths they must identify the stick used so that anybody will know in what "unit" the measurement was made. Ask the children how they might identify each unit.

Have the children recognize that they are distinguished from one another in the classroom by their names. Let the children decide how to distinguish their sticks. Some children might like to give names to their sticks (see Figure 1). Let them decide.

Ask each group to use its unit to measure some object's length—the top of a table or desk, the width of a door, or whatever is convenient. On the chalkboard make a table like Figure 1 to record the measurements as they are reported. These measurements correspond to the results for a table 240 centimeters long. The metric designations in Figure 1 need not appear on your table, nor be used by the children.

Repeat this activity with as many other objects as you think will be desirable and interesting for the children.

Materials

Measuring sticks, 42, unmarked, six of each length: 5-cm, 10-cm, 15-cm, 30-cm, 50-cm, 75-cm, and 100-cm (*Module 24*)

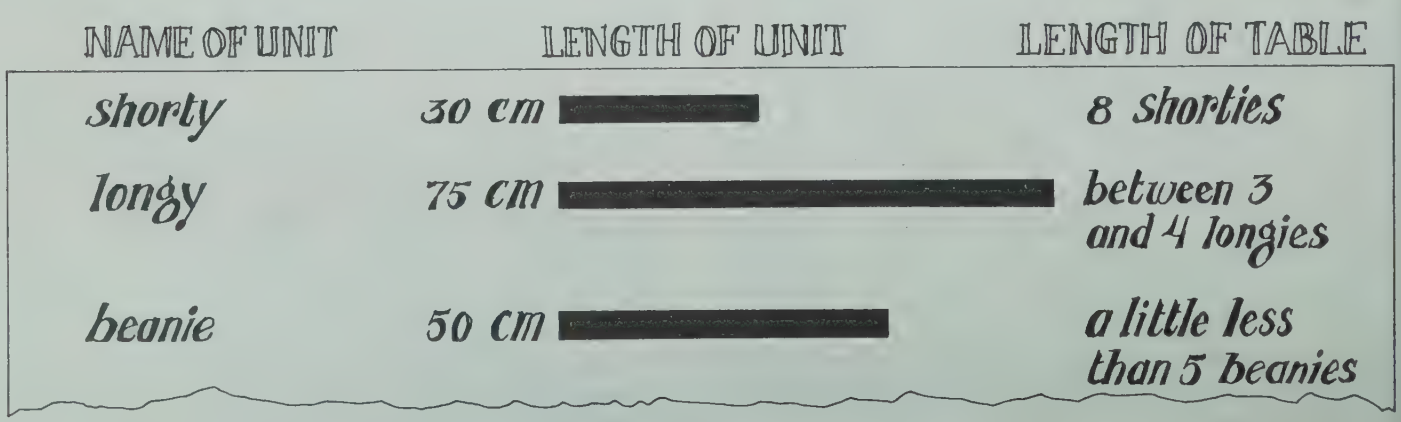

FIGURE 1

Activity 3

Cut several strips of masking tape, each strip the same length—a little over 1.5 meters long. Place the strips on the floor in different areas of the room. Have the children work in groups, using different stick lengths in *Activity 1*. Have the children use their measuring sticks to measure the lengths of new pencils and the length of the tapes on the floor. Give the groups several minutes to work independently.

Then have the children watch the members of the group with the 50-centimeter sticks as they measure their pencils again. This group will probably have difficulty making the measurements because the unit is so much longer than the pencils. The children may report the measurement in a statement such as this: The pencils are less than one stick long.

Next, have the group with the 5-centimeter sticks measure the pencils while the others watch. This group will be able to get a more accurate measurement of the pencils than the first group. The children will probably report the measurement in a statement such as: The pencil is three sticks and a little more.

Put a 50-centimeter stick and four 5-centimeter sticks beside the pencil to show that the 5-centimeter stick is the more suitable unit for measuring the pencil.

Now ask the groups with the 100-centimeter sticks and 15-centimeter sticks to report their measurements of the tapes. Discuss their results. Lay the 100-centimeter sticks end-to-end along one side of one of the tapes and the 15-centimeter sticks end-to-end along the other side. Ask the children which unit is more suitable for measuring the tape. They should see that the 15-centimeter stick will give a more accurate measurement.

Materials

Masking tape, 1 roll
Measuring sticks, 42, unmarked, six of each length: 5-cm, 10-cm, 15-cm, 30-cm, 50-cm, 75-cm, and 100-cm (*Module 24*)
Pencils, 1 for each child, new

Activity 4

Show the children an unmarked 100-centimeter measuring stick, and point out that the distance the stick represents is called a *meter*. Emphasize that a meter is one unit of linear measure in the metric system. Select volunteers to measure the width of the room. Ask the children why anyone would want to know the width and length of a room. Prepare the children for problems they may encounter in making their measurements by asking such questions as:

Where should you measure the room?
Will you need to remove any furnishings?
Is the measuring stick an appropriate unit? Why?

Repeat the procedure at least one more time with another volunteer group. Record the findings of each group and compare the results.

Show the children a rectangular piece of construction paper about 20 by 30 centimeters. Ask whether or not the measuring stick would be a suitable unit for measuring the paper's length and width. Someone may suggest that the measuring stick could be divided into a number of equal units, and that one of these equal units could then be used as a unit of measure. (See Figure 2.) If the children do not make this suggestion, you should do so and ask them for their reactions.

To illustrate or to test this suggestion, you might use a cardboard strip 1 meter long and cut it into ten equal parts. Or, you could put ten 1-decimeter sticks end-to-end along a meterstick. Emphasize the meaning of the term *meter* and *decimeter* by having the children compare a meterstick and a stick 1 decimeter long. Explain that the prefix *deci* means "one tenth." The children should relate this prefix to the division of the meterstick into ten sticks of equal lengths, each stick representing the distance called a *decimeter.*

Materials

Measuring stick, 1, 100-cm, unmarked (*Module 24*)
Construction paper, 1 sheet about 20 × 30 cm
Measuring sticks, 10, 10-cm, unmarked (*Module 24*) or cardboard strip, 1-m

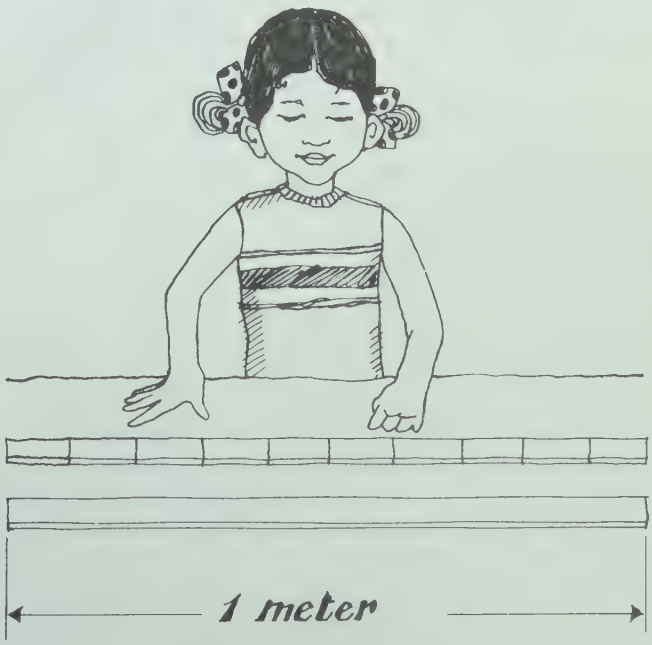

FIGURE 2

Activity 5

Like *Activity 3*, this activity gives the children experience in recognizing the necessity for selecting an appropriate unit for making a given linear measurement.

Ask each group to use a decimeter stick to measure their own pencils. Depending on how worn the pencils are, the measurements will be between 0 and 1, or between 1 and 2 decimeters. Ask how good an idea the children would have about the length of a pencil if you said that it is between 0 and 1 decimeter long. The children should respond that they would have only a very rough idea of how long the pencil really is. Ask how you might give better information. (Use a smaller unit.)

Give each group ten 1-centimeter cubes. Tell the children that these are centimeter cubes, but do not tell them that 10-centimeters is the same as 1 decimeter. Have the groups measure their pencils again and express their results in centimeters. Again call attention to the procedure of reporting measurements that fall between whole units; "between 4 and 5 centimeters."

Ask the children whether they think centimeter cubes would be convenient units to use for measuring the length of the room. The class probably will agree that using the cubes would be tedious. Ask how an appropriate unit might be selected. Have the class discuss the suggestions. You might suggest, if no child does, that a unit be selected that will result in a measurement of two units or more.

Next, ask the groups to use the cubes to measure the decimeter sticks. Ask how many 1-centimeter cubes can be put end-to-end along a decimeter stick. The children should see that 10-centimeters is the same as 1 decimeter. Review the relationship between the meter and the decimeter, and the corresponding relationship between the decimeter and the centimeter. You may want to repeat the arrangement of ten decimeter sticks end-to-end to show their equivalence with a meter.

Materials

Measuring sticks, 10, 10-cm, unmarked (*Module 24*)
Pencils, 1 for each group
Cubes, 100, 1-cm (*Module 30*)

Activity 6

Ask each child to draw one of his hands by outlining the hand on a piece of paper with a pencil. Then ask each one to use the centimeter cubes to measure the width of one of their fingers, and the decimeter stick to measure the length of one of their hands. Let the children decide how they want to measure the length of the hand. (Perhaps from the middle of the wrist bone to the end of the middle finger.) Suggest each child measure the other hand to discover whether both hands are the same length. A finger will be about 1 centimeter wide and a hand, about 1 decimeter long. This activity should strengthen the children's concept of the size of these units.

To give additional practice in using the meter, decimeter, and centimeter, have the children make some vertical measurements. Have them see how high a meterstick reaches on their bodies when the stick is placed vertically on the floor. Discuss the need for vertical as well as horizontal measurements (a person's height, and the height of doors, buildings, and so on). Then select various objects for vertical measurement. Introduce the terms *vertical* and *horizontal* if your children are ready for them. If not, talk about *height*, *length*, and *width*.

Materials

Cubes, 100, 1-cm (*Module 30*)
Drawing paper, 1 sheet for each child
Measuring sticks, 30, 10-cm, unmarked (*Module 24*)
Measuring sticks, 15, 100-cm, unmarked (*Module 24*)

Generalizing Experience

Children will become accustomed to measuring and thinking in metric units only if they make metric measurements frequently. Give the children many opportunities to measure familiar things using metric units. There are many things to measure and many ways to incorporate measurement skills into school activities. One interesting activity is to measure first the span of a child's outstretched arms from fingertip to fingertip, and then to measure the same child's height. For most people, the two measurements tend to be almost identical.

APPRAISAL

1. With chalk or masking tape, mark off a line about 2 meters long on the floor. Construct the line so that regardless of which of two measuring sticks (one long and one short) is used, the children's measurements will not be an even number of stick-lengths. Ask individuals or small groups to select either the long or short measuring stick and to use this stick to measure the length of the line. Have the children state the length of the line in stick-lengths. Be sure children express the length of the line by stating maximum or approximate whole numbers of stick-lengths.

Have individuals or small groups use the other measuring stick and repeat the measurement. Again, the children should give their results in maximum or approximate whole numbers of stick-lengths.

Ask for volunteers to explain why two different sets or results were obtained.

2. Ask each child to estimate the length of a book or similar object. Then ask him to choose a metric unit or units, and measure the object's length and width. He should select units appropriate to the measurement he is making, and report the measurements in correct units.

3. Ask each child to name three metric units of linear measure, the centimeter, decimeter, and meter. Then, have each child use fingers, hands, and arms to demonstrate the approximate length of each unit.

Materials

Masking tape, 1 roll, or chalk
Measuring sticks, 12, unmarked, six of each length: 5-cm and 75-cm (*Module 24*)
Book, 1, or similar object
Measuring stick, 1, 10-cm, unmarked (*Module 24*)

COMPETENCY MEASURE

TASK 1 (Objective 1): Put a strip of masking tape about 150 centimeters long on the edge of a table. Give the child the 50-centimeter measuring stick and say, Count the number of times the stick can be laid end-to-end along the tape. The child should correctly count the number of times the stick can be laid end-to-end on the tape.

TASK 2 (Objective 2): Show the child a meterstick marked in centimeters. Hold it by its ends so that the entire length is between your hands. Ask, What is the name of this unit of measure? The child should say that it is a meter.

TASK 3 (Objective 3): Give the child a decimeter ruler marked in centimeters, an unmarked 10-centimeter measuring stick, and an unmarked 100-centimeter measuring stick that you have marked in decimeter segments. Show the child a paper with a 7-centimeter line segment drawn on it. Say, Choose the best measuring stick to use for measuring the line on this paper. The child should identify the decimeter ruler marked in centimeters.

TASK 4 (Objective 4): Make sure a meterstick is visible in the room. Say, Measure the width of this room in metric units. Point to the dimension as you say it. If the child asks to use a second stick or a piece of chalk to indicate the terminating point of each meter, let him do this. The child should select a meterstick and lay it along the floor to accurately measure the width of the room.

Materials

Masking tape, 1 roll
Measuring sticks, 3, unmarked, one of each length: 10-cm, 50-cm, and 100-cm (*Module 24*)
(Note: Use masking tape and marking pen to mark the 100-cm stick into decimeter segments.)
Meterstick, 1 (*Module 24*)
Decimeter ruler, 1, marked in centimeters (*Module 24*)
Paper, 1 sheet, marked with a 7-cm line segment

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24 Measuring

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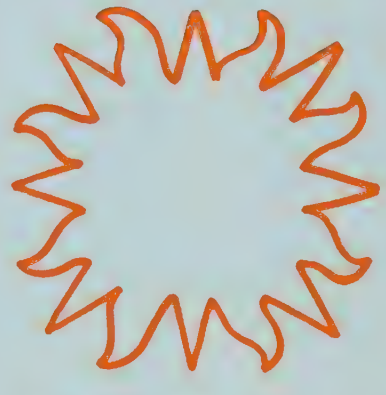

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SCIENCE... A PROCESS APPROACH II

MODULE

25

Communicating/b

Introduction to Graphing

OBJECTIVES

At the end of this module the child should be able to

1. *CONSTRUCT* a bar graph.
2. *NAME* the number of items represented by the bars of a bar graph.

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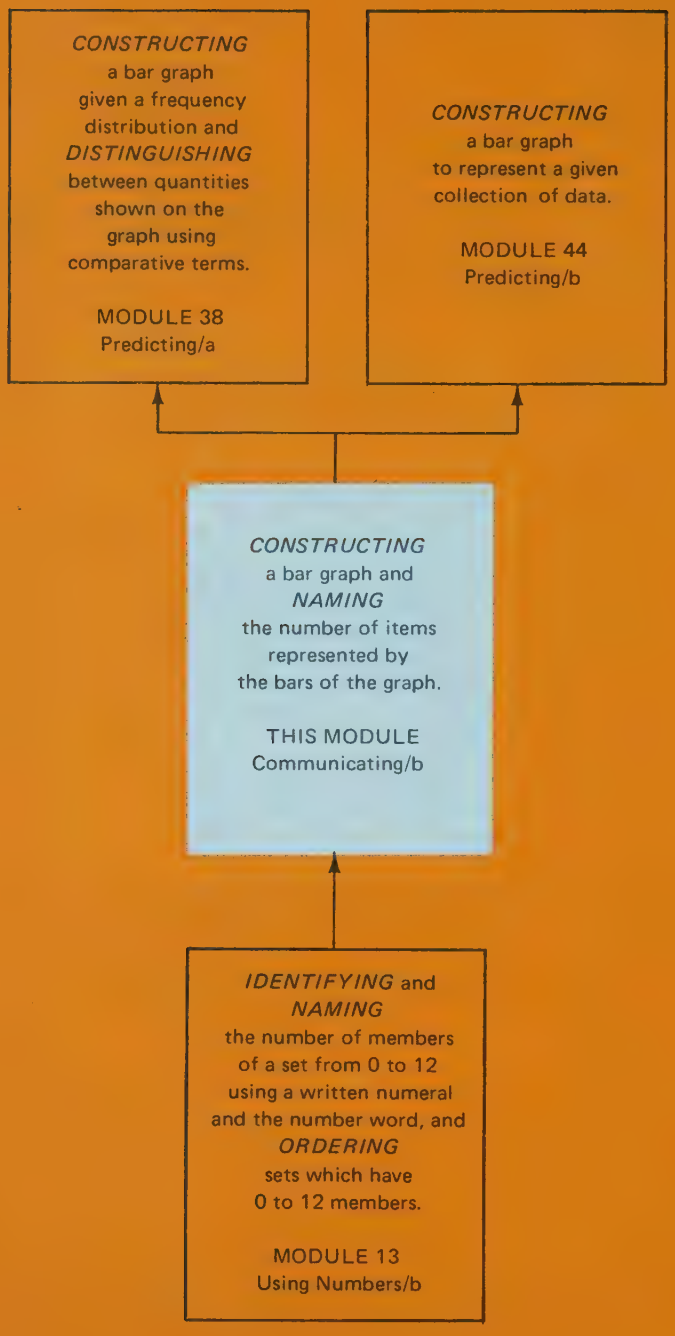
SEQUENCE



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RATIONALE

Graphing is a technique commonly used for communicating the results of an investigation, because a graph conveys a great deal of information efficiently. Children construct and use graphs in many of the modules of *Science . . . A Process Approach.* In this module the child is introduced to the simple bar graph as a convenient way to picture a classification scheme. Other techniques of graphic representation will be developed in later modules.

As the children work through the activities of this module, they will construct graphs and read graphs that others have constructed. In order that these graphs communicate as simply and directly as possible, it is suggested that certain "rules" be followed. You should make it clear to the children that these rules are really agreements based on convention. Some children may wish to try to communicate using other rules. If so, let them try, and then ask the group to help them decide whether the new rules are better. They probably will not be. The suggested rules are as follows.

1. Start all bars at the common base line.
2. Place the common base line at the "zero" level of the vertical number line.
3. Make the numbers on the vertical number line correspond to the horizontal lines of the grid, not to the spaces between them.
4. Use labels to show the kind of information shown along the vertical number line and along the horizontal base line.
5. Each bar is two squares wide and centered on a vertical grid line.
6. Label each bar with appropriate descriptive information. Center each label under its bar. See Figure 1.

Make a special effort to spark the children's interest in graphs they construct and in graphs shown to them by others. The children will sometimes be more interested in using data that they collect themselves than in using data collected by others. However, since the children's graphing skills are at an early stage of development, help them avoid data that require a large number of bars in a single graph and large numbers along the vertical number line. Help the children learn that a graph is a way to picture information, and is thus a way to report information when the recorder is not present.

Vocabulary

graph
grid
base line
vertical
horizontal
bar
number line

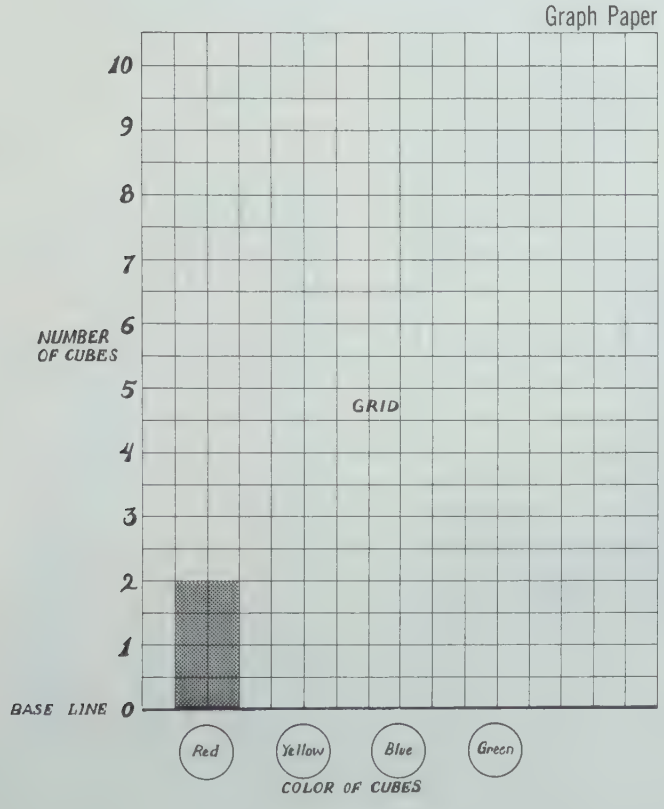

FIGURE 1

INSTRUCTIONAL PROCEDURE

Introduction

Put a box containing 29 colored cubes (see *Materials*) on a table or desk near the door. As the children enter the room, have each child select a cube from the box. When all of the children have been seated, ask those holding blue cubes to put their cubes in a pile on the table. Then ask those holding red cubes to make another pile. Repeat this for the other colors.

Select several children (one for each cube color) to come forward. You might select the children so that color of dress or shirt matches cube color. Ask those children to stack the cubes of each color, one on top of the other. When the cubes are in stacks, ask other children (one for each color) to come forward, count the number of cubes in each stack, and select the appropriate numeral card to put beside the stack (see Figure 2).

Ask the children to suggest ways in which they can remember the number of cubes in each stack after you clear off the table and put the cubes away. Let the children try any method that they suggest before you clear away the cubes. Whether or not the children have suggested it, tell them that tomorrow they will work with the cubes again, and will plan a way to draw a picture that will provide information about the number of cubes in any given stack.

Materials

Cubes, 29, 3-cm, plastic, 8 red, 10 yellow, 9 blue, and 2 green (*Module 25*)
Numeral cards, 10, one each of numerals 1 to 10

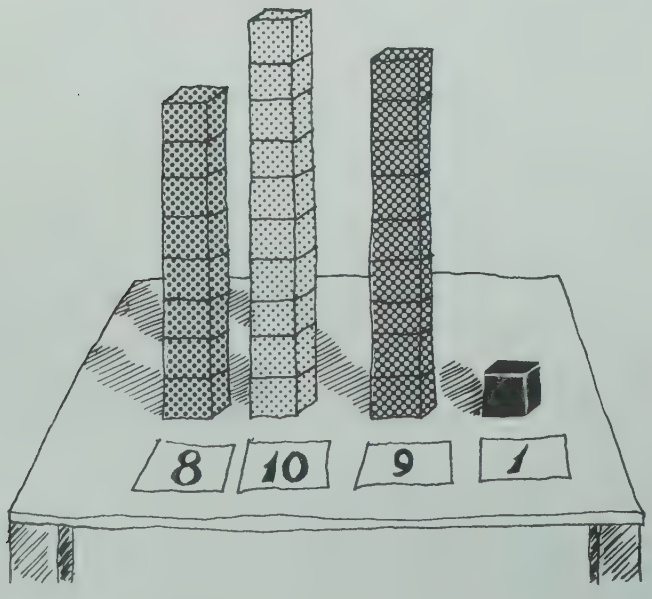

FIGURE 2

Activity 1

Provide the same cubes as those used in the introductory activity. Have each child select a cube and a felt square of the same color. Then have the children place the cubes of the same color together in a neat stack. In order to associate the stacks of cubes with the bars to be arranged on the flannel board, have the children start the stacks near the flannel board. After each child has added a cube to the stack of cubes of the same color, ask him to add a felt square to the column of squares of the same color on the flannel board. Help the children place the squares close together and in straight columns. When all of the squares have been placed, there will be several columns of squares—red, blue, yellow, and so on—on the flannel board. The number of squares in each column will correspond to the number of cubes in each stack.

Have the children count the felt squares in each column on the flannel board. Tell them that the display of felt squares is called a graph. Explain that, in this graph, the number of felt squares of any one color is the same as the number of cubes of that color that were stacked by the children. Encourage the children to use the word *graph.* Remove the stacks of cubes, and then ask how many red cubes there were and how many blue cubes. The children should see that the information about the numbers is "stored" on the flannel-board graph.

To help the children transfer their new skills, repeat this activity using colored, plastic toy cars and the colored felt squares. The children should make stacks of cars and use the felt squares to graph the numbers of cars on the flannel board.

Materials

Cubes, 29, 3-cm, plastic, 8 red, 10 yellow, 9 blue, and 2 green (*Module 25*)
Squares, 37, felt, 10 red, 10 yellow, 9 blue, and 8 green (*Module 25*)
Flannel board, 1
Toy cars, 30, plastic, 10 red, 7 yellow, 5 blue, and 8 green (*Module 25*)

Activity 2

Distribute a collection of colored cubes to the children, one cube to each child. There should be only one cube of one of the colors, but more than one cube of all the other colors. Also give each child a felt square. All the squares should be the same color, and this color should be different from that of any of the cubes. (See *Materials*.) Ask the children to make a graph. You might suggest that the children having red cubes begin the graph by putting their felt squares on the flannel board. Do not have the children stack their cubes.

The children should have no difficulty until they begin to construct a bar to represent cubes of a second color. At this point, call the children's attention to the need to differentiate between the bars for the different colored cubes. Introduce the idea of labeling each bar. Have the children suggest an appropriate labeling system. One effective method is the use of felt circles that are the same colors as the cubes. (See Figure 3.) After the children put the circles in place, they can position the felt squares on the graph above the appropriate circles of colored felt.

Ask questions about the graph to learn if the children can read it to find the number of cubes of each color. If you wish, follow this activity with a similar activity using plastic toy cars in place of the cubes.

Materials

Cubes, 28, 3-cm, plastic, 8 red, 10 yellow, 9 blue, and 1 green (*Module 25*)
Flannel board, 1
Squares, 28, felt, orange (*Module 25*)
Circles, 4, felt, one of each color: red, yellow, blue, and green (*Module 25*)

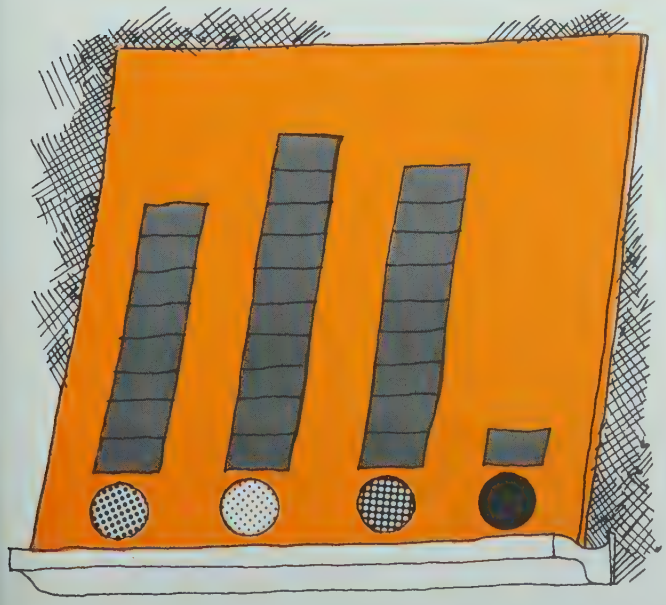

FIGURE 3

Activity 3

On the chalkboard or a large sheet of paper, draw a grid with lines about 4 centimeters apart. If you have an overhead projector you might prefer to use the supplied graph-paper transparency. Now draw the bars on the grid as in Figure 3. Make labels for the bars similar to those used for the flannel-board graph. Then give each child a sheet of graph paper on which you have drawn and labeled a heavy base line.

Ask the children to make labels for the bars on their graphs. The labels should be colored like the ones on the chalkboard, large paper grid, or transparency. Ask the children how their graph paper might be useful for representing the number of colored cubes. If necessary, suggest that each 2-centimeter square (four 1-centimeter squares) on the graph paper represent one of the felt squares on the flannel-board graph.

Show the children how to color the 2-centimeter squares. As you color the graph on the chalkboard, on the large paper grid, or on the transparency, have the children color their graphs. When the coloring is finished, the bar graph should look something like the graph made with felt squares and circles in *Activity 2*. Have the children compare their own graphs with the flannel-board graph.

Next, ask if the children can think of a way to improve their graphs so that they can tell how many cubes there are of each color. If the children do not suggest using numerals, ask them how they could use numerals to help them count the number of cubes represented on the graphs. The idea of putting a vertical number line along the side of the graph should gradually emerge. Point to the base line and ask how the base line should be numbered. The base line represents an empty set of cubes, or zero. Put the vertical number line on the graph. Be sure that the numerals lie adjacent to the horizontal lines of the grid, not between them (see Figure 4 on the next page).

Now ask the children whether the graph tells how many cubes there are of each color. Ask if the graph is easier to read now. Point out the labels "Number of cubes" and "Color of cubes."

Materials

Graph Paper, 1 spirit master (*Module 25*)
Transparency, 1, duplicate of *Graph Paper* (*Module 25*)
Crayons, 1 box for each child
Pencils, 1 for each child
Transparency markers or colored chalk, 4 colors and black

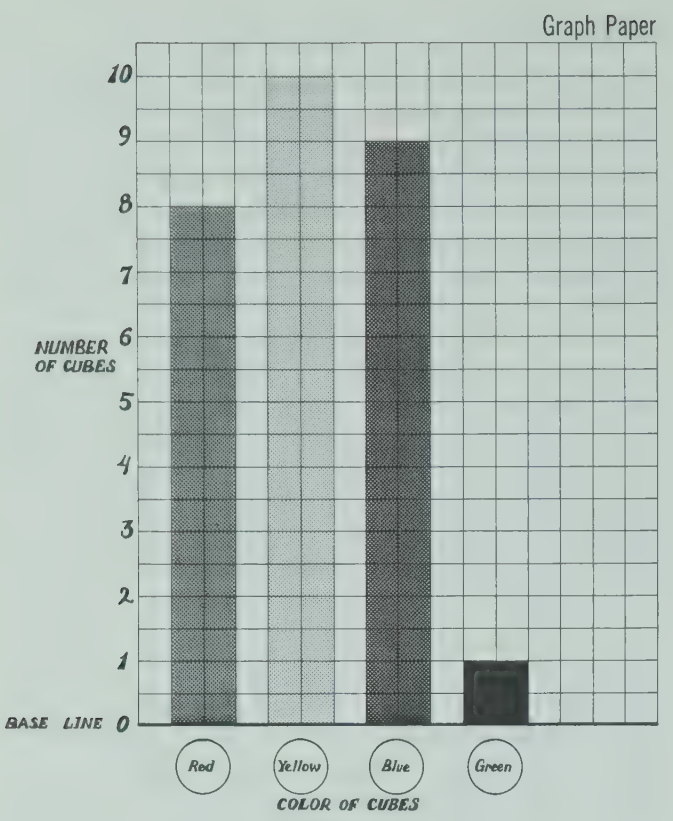

FIGURE 4

3. Use a label such as "Number of stones" along the vertical number line and a label such as "Person's name" along the horizontal base line.
4. Begin each bar at the base line.
5. Construct each bar by shading or coloring the number of squares that corresponds to the number of stones each child picked out.
6. Label each bar to identify the four children.

After the children have made their graphs, ask questions that the children can answer by reading their graphs. You might ask such questions as: Which bar is tallest? Who picked up the most stones? How many stones did . . . . pick up? Try to get the children to read the graph by comparing the top of a bar with the number line rather than by counting the number of colored squares in a bar. To encourage the children to use the number line, cover all but the top square of a bar, and ask the children to tell you the number of stones the bar represents.

Materials

Graph Paper, 1 spirit master (*Module 25*)
Container, 1, 1-liter (*Module 16*)
Stones or other small objects, quantity sufficient to almost fill container
Pencils, 1 for each child

Activity 4

Give each child a sheet of graph paper. Put a container almost filled with small stones or other small objects on your desk. (The children might like to collect their own data, in which case data suggested in the *Generalizing Experience* might be substituted for the data proposed here.)

Ask each of four children to take a handful of stones from the container. Have each child count the number of stones he has picked up. Now ask the children how to make a graph to show the number of stones each person picked out of the container. The discussion should lead to the need for a label that identifies each child's stones.

After the children agree on labels, have each child make his own graph of the information. Have the children use a 2-centimeter square (four 1-centimeter squares) to represent one stone.

Give the children individual help as they work. Check that the children remember the following rules:

1. Use a vertical number line.
2. Make the numerals of the number line correspond to the lines of the grid, not to the spaces between them.

Generalizing Experience

Supply the children with graph paper, and suggest that they decide what kind of data they want to graph. Some suggestions are the number of science books three or four children in the room have read; the number of rainy, cloudy, and clear days in the previous two weeks; the number of birthdays of the children in the class during three or four months of the year, or during each of the four seasons; the number of boys and girls in the classroom. Have the children compare their graphs. Encourage the children to graph different information so that not more than five children graph the same data. Have each child read another child's graph or answer questions about the graph. Review the correct use of labels and other graphing "rules" discussed earlier.

Materials

Graph Paper, 1 spirit master (*Module 25*)
Pencils, 1 for each child

APPRAISAL

Provide a container filled with a mixture of items of four kinds or of four colors. Have each child take a sample and then graph the sample, showing the number of items of each kind or color. Finally, have the children read their graphs as they discuss the kinds or colors of items in each sample, who drew the most items, and so on.

Materials

Container, 1, 2-liter (*Module 28*)
(Note: Fill the container with a mixture of items of 4 kinds or of 4 colors. For example, use 4 kinds of seeds or nuts or small shapes or use 4 colors of gravel or pencils or marbles.)

COMPETENCY MEASURE

Give the child three different kinds of items—five of one, four of another, and one of the third. Also give the child a piece of graph paper and a crayon.

TASK 1 (Objective 1): Say to the child, Draw three bars to show the number of items of each kind (you name the items). The child should draw the bars correctly along separate vertical lines of the graph paper.

TASK 2 (Objective 1): Say to the child, Number the lines on the graph paper so that I can tell how many items of each kind there are. The child should number the lines correctly.

TASK 3 (Objective 1): Say, Label the bars so that your mother could tell what items you have. The child should label the bars satisfactorily.

TASK 4 (Objective 2): Give the child a graph drawn by one of the other children and ask, How many items are represented by two of the bars in the graph? The child should respond correctly.

Materials

Items, 10, five of one kind, four of another, and one of a third
Graph Paper, 1 spirit master (*Module 25*)
Crayon, 1
Graph, 1, drawn by one of the children, showing at least two bars

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25 Communicating/b

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SCIENCE... A PROCESS APPROACH II

MODULE

26

Measuring/d

Using a Balance

OBJECTIVES

At the end of this module the child should be able to

1. *ORDER* objects of appreciably different weights by lifting them and by comparing them on an equal-arm balance.
2. *STATE THE RULE* that the earth-pull on the heavier of two objects is greater than it is on the lighter object.
3. *DEMONSTRATE* how to compare the weight of small objects by counting the number of arbitrary units, such as cubes, needed to balance the objects on an equal-arm balance.
4. *DESCRIBE* the results of measurements, by saying, for example, "The object weighs the same as six cubes," or "The object weighs more than ten cubes but less than eleven cubes."

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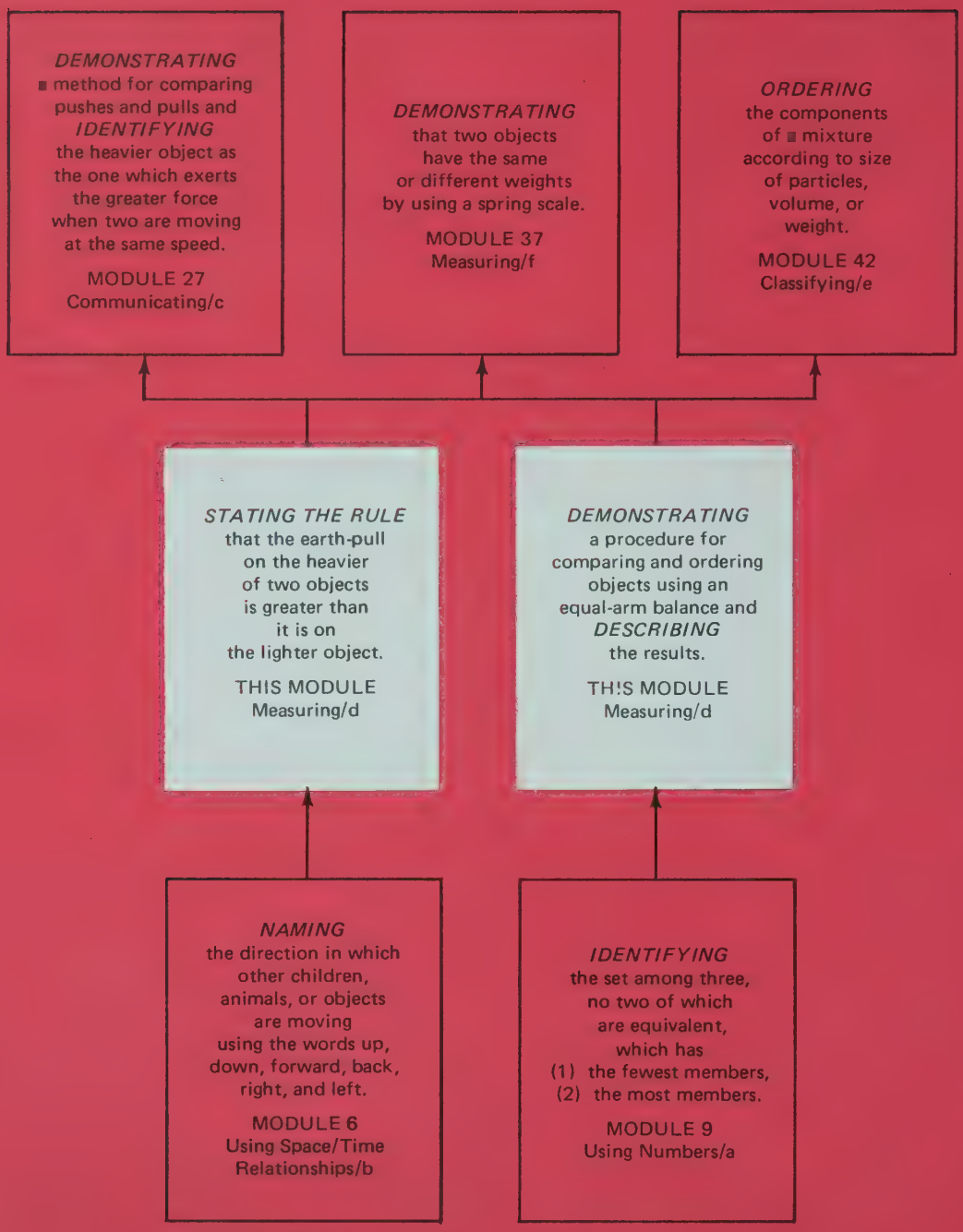
SEQUENCE


DEMONSTRATING
■ method for comparing pushes and pulls and *IDENTIFYING* the heavier object as the one which exerts the greater force when two are moving at the same speed.
MODULE 27
Communicating/c
DEMONSTRATING that two objects have the same or different weights by using a spring scale.
MODULE 37
Measuring/f
ORDERING the components of ■ mixture according to size of particles, volume, or weight.
MODULE 42
Classifying/e
STATING THE RULE that the earth-pull on the heavier of two objects is greater than it is on the lighter object.
THIS MODULE
Measuring/d
DEMONSTRATING a procedure for comparing and ordering objects using an equal-arm balance and *DESCRIBING* the results.
THIS MODULE
Measuring/d
NAMING the direction in which other children, animals, or objects are moving using the words up, down, forward, back, right, and left.
MODULE 6
Using Space/Time Relationships/b
IDENTIFYING the set among three, no two of which are equivalent, which has (1) the fewest members, (2) the most members.
MODULE 9
Using Numbers/a

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

In this module the children compare objects on the basis of weight by lifting them and by using an equal-arm balance. In previous modules children have compared objects by measuring lengths and volumes.

The simplest way to compare objects according to their weight is to first lift them and then arrange them in an order based on how heavy they feel. The children order common objects from heaviest to lightest in the *Introduction.*

The purpose of *Activity 1* is to have the children interpret weight as a force resulting from the pull of the earth on objects. Once the children recognize that an object pushes down on a supporting surface because the earth pulls down on that object, they will be able to explain that the object with the greater earth-pull is the heavier one.

When the two objects being compared have nearly the same weight, a precise method of comparison is desirable. The equal-arm balance (see Figure 1) is introduced to provide this precision. Two objects having the same weight will balance each other if they are placed on opposite pans of an equal-arm balance. But, if one of the objects is heavier, the two will not balance: the pan containing the heavier object will go down and the other will go up. Thus, the equal-arm balance is useful for determining whether the two objects weigh the same and, if they do not, which is the heavier. The comparison may be made directly, or indirectly by comparing the weight of the objects by counting the number of arbitrary units, such as small cubes, needed to balance each of the objects.

Two modes of instruction for the use of the balance are suggested for introducing the children to the balance and for providing them with practice in using the balance. One mode is auto-instruction; the other is group instruction. *Activity 3* and *Activity 4* utilize auto-instructional booklets that a child may use independently or with a partner. *Activity 2* and *Activity 5* feature group instruction. In design and in the materials used, *Activity 2* is similar to *Activity 3,* and *Activity 5* is similar to *Activity 4.* Because of these similarities, there is a wide range of management possibilities. For example, you may wish to use only one mode with all the children, or you may want some children to work in groups while others are working individually. Furthermore, a child needing reinforcement or review might work independently, or with a partner, after having participated in the group activities.

Vocabulary

lightest	equal-arm balance
heaviest	weigh
weight	balance
force	
earth-pull	

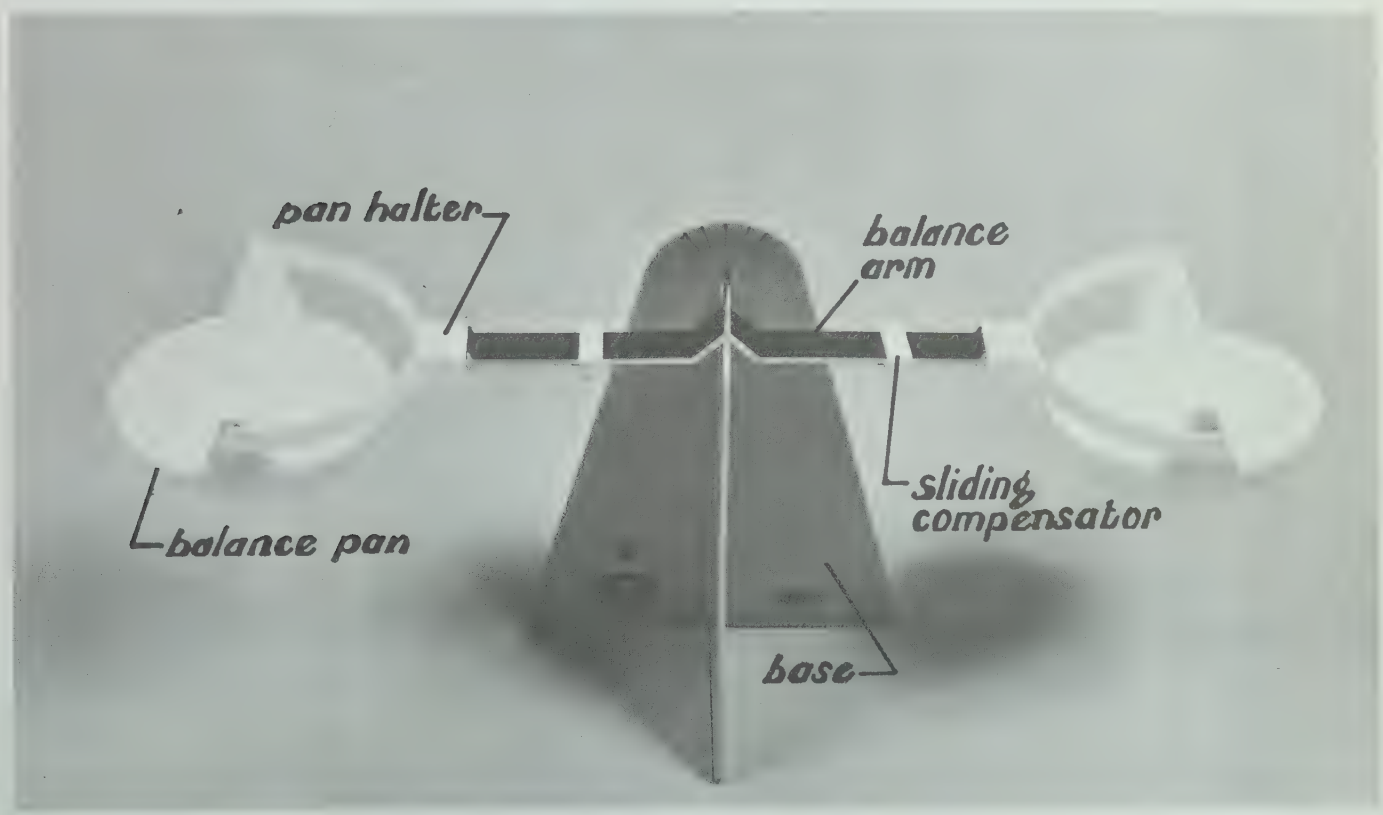


FIGURE 1

INSTRUCTIONAL PROCEDURE

Introduction

On a table before the children, arrange a collection of common objects that are sufficiently different in weight so that the children can order them from lightest to heaviest by lifting them. Have one or two children try to arrange the objects in order from lightest to heaviest, and ask the others if they agree with the ordering.

Then extend this lifting and ordering activity to include a series of objects that look alike and have about the same volume, but "feel" different when they are lifted because some are heavier than others. Coffee cans with plastic lids or similar containers filled with different amounts of sand might be used.

Materials

Brick, 1
Cube, 1, 5-cm (*Module 26*)
Baseball, 1
Styrofoam ball, 1 (*Module 26*)
Table tennis ball, 1 (*Module 26*)
Coffee cans with plastic lids, several, or similar containers
Sand, 1 bag (*Module 26*)

Activity 1

In this activity the children begin to interpret weight as a force down, or earth-pull, and are encouraged to use the word *force*. The questions and answers suggested in this activity are intended as a guide for developing ideas concerning weight and force. Rephrase, reorder, and supplement them as you think appropriate.

Put two identical closed boxes containing different numbers of books on a table in front of the children. Have several children lift both of them. Ask questions such as the following:

Is there any difference? (One is heavier than the other.)

How do you know? (One is harder to lift.)

What must you do to hold the box? Do you have to push or pull on the box? What is another word that means either a push or a pull? (Force.)

You exerted or applied a force to the box in order to hold it. Does the box apply a force to your hand? Do you feel the box pushing down on your hand? (Yes.)

Which of the two boxes pushed harder on your hand? (The heavier one.)

Why do the boxes push down when you hold them? Why do they fall if you let them go?

If the children answer "because of gravity," encourage them to say "because of earth-pull," since gravity is *not* another word for earth-pull. Try to get the children to talk about forces.

Is earth-pull a force? (Yes.)

What is the force pulling on? (The box.)

What causes the force? (The earth.)

The descriptive term *earth-pull* clearly implies that the force being described is connected with the earth. The box with the greater earth-pull is the heavier; it has the greater weight. The weight of an object is a measure of the earth-pull. To compare the weights of two objects, it is necessary to compare the forces with which they push down on whatever holds them.

Have each child lift two objects of quite different weight, one in each hand. Have the children feel the different force with which the two objects push or pull down on their hands, and then ask them to make a comparison. They may say something like, "This object is heavier than that one. I know, because it pushes harder on my hand." "The earth-pull on this object is greater than on that one." Encourage all the children to give this kind of description during the remainder of the module and whenever they are comparing weights in other contexts.

Materials

Boxes, 2, large enough to hold books
Books, several
Objects, several pairs each of quite different weight

Activity 2

This activity, featuring group instruction, is similar in design to *Activity 3* that features auto-instruction. You may wish to use *Activity 3* as an alternative to this activity.

Repeat the activity in the *Introduction* by using a book, a drinking straw, a box of crayons, a ruler, and a chalkboard eraser; have the children arrange the items in order from the lightest to the heaviest. After this review, separate the children into groups and provide each group with an equal-arm balance. Also give each group an identical collection of small objects to be weighed (see *Materials*). Some objects should weigh the same or nearly the same. Marbles and balls are not recommended because they roll too easily. Ask the children to compare and order the assorted objects by using the balance. Give the children considerable freedom to experiment with the balance, even to the extent of permitting them to use measuring techniques that you know are wrong. They will later become aware of errors they have made when the groups compare their results.

After the children have had sufficient time to experiment, ask someone from each group to report to the others the order into which the group put the objects. Have them report their comparisons by saying "the bolt weighs more than the slug," "the washer weighs less than the screw," or "the bolt is balanced by the car and the cube." If there are disagreements, have the members of one of the groups demonstrate how they made their measurements, and have the children discuss the procedure that the group used. Variations in results may be due to any one of the following factors:

The children may have used a balance that was not correctly adjusted. The sliding compensators should be positioned so that when the pans are empty the balance arm is level.

The children may have made incorrect inferences because they compared objects indirectly.

Some minor variations in weight may exist among objects of the same kind.

Discuss the results and disagreements, and try to have the class decide on the proper technique for using the balance. If a suggestion is incorrect, let the children carry out further comparisons or demonstrate that this technique leads to incorrect or contradictory results. If a suggestion is correct, let the children demonstrate that it leads to correct results.

At the end of this activity, you may want the children to use the response sheet *Making Comparisons. Balancing 1* although this sheet was designed for use primarily in *Activity 3* with the auto-instructional booklet *Balancing 1.*

Materials

Book, 1
Drinking straw, 1
Crayons, 1 box
Metric ruler, 1 (*Module 27*)
Chalkboard eraser, 1
Equal-arm balances, 5, each consisting of a base, balance arm, two balance pans, two pan halters, and two sliding compensators (*Module 26*)
Small objects, to be weighed
- Toy cars, 5 (*Module 25*)
- Washer, bolt, screw, and slug, 5 of each *(Module 26)*
- Cubes, 5, 3-cm (*Module 25*)
- Bar magnets, 5 (*Module 27*)
- Hand lenses, 5 (*Module 19*)
- Nuts, 5, metal (*Module 27*)

Making Comparisons, Balancing 1, 1 spirit master, (*Module 26*) (optional)

Pencils, 1 for each child (optional)

Activity 3 and Activity 4

These activities each utilize an auto-instructional booklet, and might be considered as alternates to the group activities presented in *Activity 2* and *Activity 5.*

The booklets, *Balancing 1* and *Balancing 2,* use pictures to tell unfinished stories. Each booklet is correlated to a response sheet that facilitates the child's completion of the story. With minimal instructions from you, a child working alone or with a partner can "read" the unfinished picture stories, and work with the items that accompany each booklet to finish the stories. The stories should be read and finished, one at a time in order as numbered. When one story is finished satisfactorily, the children may go on to the next. You might suggest that the children give titles to the stories. The stories might be titled as follows:

Balancing 1

Story 1 Ordering Objects from the Lightest to the Heaviest by Lifting Them
Story 2 Ordering Another Set of Objects from the Lightest to the Heaviest by Lifting Them
Story 3 Assembling the Balance
Story 4 Adjusting the Balance
Story 5 Using the Balance to Order Objects from the Lightest to the Heaviest

Balancing 2

Story 6 Counting the Number of Standard Units (Cubes) Necessary to Balance Each Member of a Set of Objects
Story 7 Using the Balance and Supplied Standard Units (Cubes) to Order a Set of Objects from the Lightest to the Heaviest
Story 8 Counting the Number of Standard Units (Cubes) Necessary to Balance Each Member of Another Set of Objects
Story 9 Using the Balance and Supplied Standard Units (Cubes) to Order Another Set of Objects from the Lightest to the Heaviest
Story 10 Using the Balance and Standard Units (Paper Clips) to Order A Set of Objects from the Lightest to the Heaviest

The words *lightest* and *heaviest* appear repeatedly in the picture stories. Before children begin the activities make certain that they can recognize and understand the meaning of these words.

For *Activity 3,* provide each child or pair of children with an equal-arm balance, a copy of the booklet *Balancing 1,* the items that accompany the booklet (see *Materials*), a copy of the response sheet *Making Comparisons, Balancing 1,* and a pencil.

For *Activity 4,* provide each child or pair of children with an equal-arm balance, a copy of the booklet *Balancing 2,* the items that accompany the booklet (see *Materials*), a copy of the response sheets *Making Comparisons, Balancing 2,* and a pencil.

When you give the children the booklets and response sheets for the first time, point out the items that accompany the booklets and give the children directions such as those that follow:

> The pictures in the booklets tell stories. The stories are not finished. Use the materials that go with the booklets to finish the stories. Find a question mark on some pictures. The question mark tells you to finish the story by using the response sheet. Mark your answers with a pencil on the response sheet.

You might show one child how to use the response-sheets, and have that child demonstrate to another. In this way, the children can teach each other.

Making Comparisons, Balancing 1

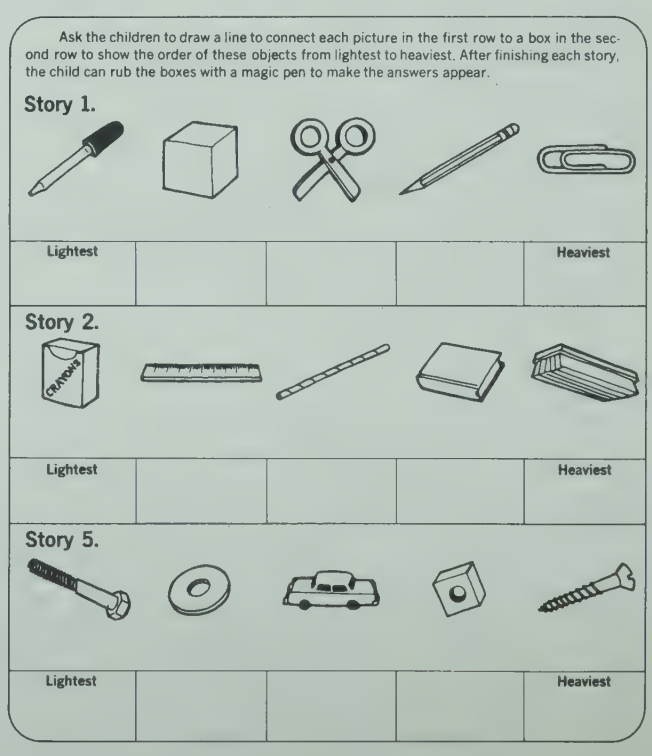

Ask the children to draw a line to connect each picture in the first row to a box in the second row to show the order of these objects from lightest to heaviest. After finishing each story, the child can rub the boxes with a magic pen to make the answers appear.
Story 1.
Lightest
Heaviest
Story 2.
CRAYONS
Lightest
Heaviest
Story 5.
Lightest
Heaviest

FIGURE 2

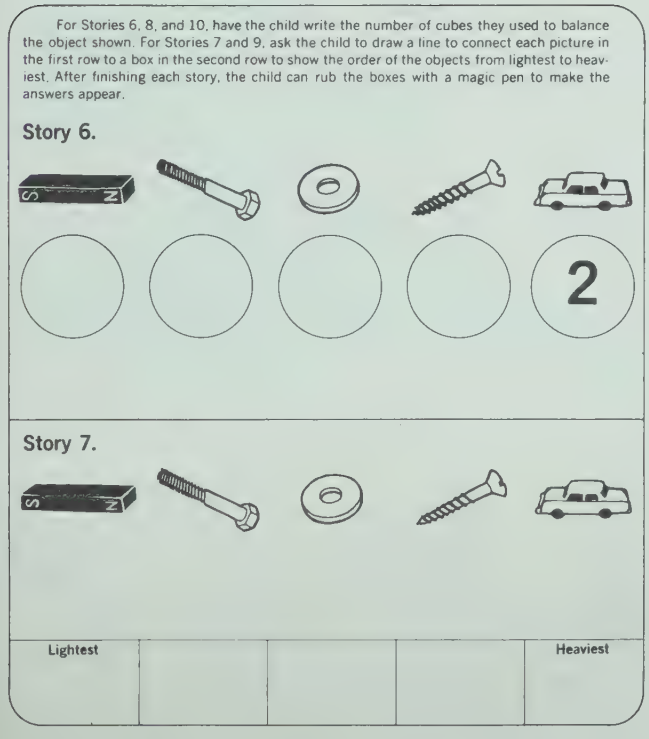
Materials

Equal-arm balances, 5, each consisting of a base, balance arm, two balance pans, two pan halters, and two sliding compensators (*Module 26*)
Balancing 1, 5 booklets (*Module 26*)
Items to accompany each copy of *Balancing 1*
- Paper clip, 1
- Dropper, 1 (*Module 28*)
- Pencil, 1
- Cube, 1, 3-cm (*Module 25*)
- Scissors, 1
- Drinking straw, 1
- Crayons, 1 box
- Metric ruler, 1 (*Module 27*)
- Chalkboard eraser, 1
- Book, 1
- Toy car, 1 (*Module 25*)
- Washer, bolt, and screw, 1 of each (*Module 26*)
- Nut, 1, metal (*Module 27*)

Balancing 2, 5 booklets (*Module 26*)
Items to accompany each copy of *Balancing 2*
- Cubes, 20, 1-cm (*Module 30*)
- Cube, 1, 3-cm (*Module 25*)
- Washer, bolt, screw, slug, and rubber stopper, 1 of each (*Module 26*)
- Hand lens, 1 (*Module 19*)
- Nut, 1, metal (*Module 27*)
- Bar magnet, 1 (*Module 27*)
- Dropper, 1 (*Module 28*)
- Paper clips, 1 box
- Toy car, 1 (*Module 25*)

Making Comparisons, Balancing 1, 1 spirit master, response sheet to accompany *Balancing 1* (*Module 26*)
Making Comparisons, Balancing 2, 2 spirit masters, response sheets to accompany *Balancing 2* (*Module 26*)
Pencils, 1 for each child

Making Comparisons, Balancing 2


For Stories 6, 8, and 10, have the child write the number of cubes they used to balance the object shown. For Stories 7 and 9, ask the child to draw a line to connect each picture in the first row to a box in the second row to show the order of the objects from lightest to heaviest. After finishing each story, the child can rub the boxes with a magic pen to make the answers appear.
Story 6.
2
Story 7.
Lightest
Heaviest

Making Comparisons, Balancing 2

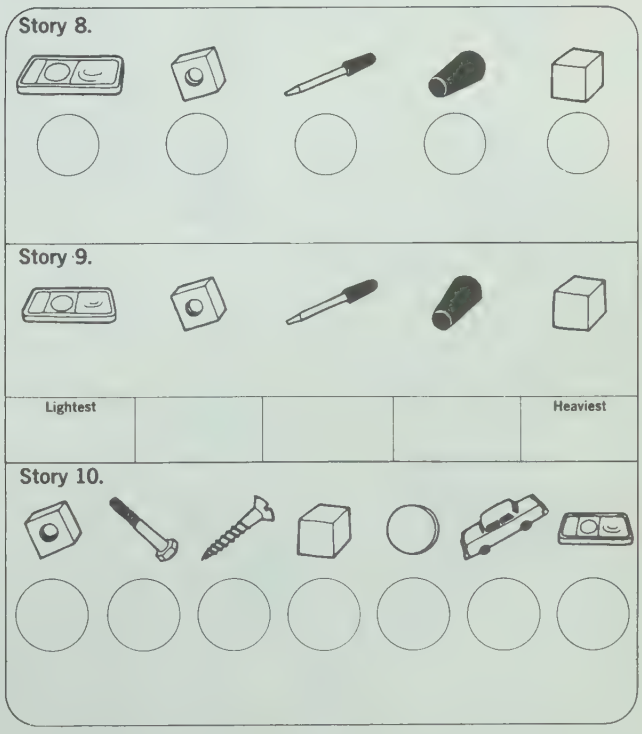


FIGURE 3

Activity 5

This activity, featuring group instruction, is similar in design to *Activity 4* that features auto-instruction. You may wish to use this activity as an alternative to *Activity 4*.

Put an object in one pan of a balance and ask the children what you might do to make the pans balance. Someone may tell you to put something more on the "up" pan or to make the force bigger on the lighter side. Follow the children's suggestion and have them see whether their idea works. If it does, ask them whether the idea leads to a measurement of the force on each pan. For example, suppose someone suggested that you push down on the "up" pan with your finger. This will make the pans balance, but will not allow a quantitative comparison of the force in each pan, because "finger-push" is variable, and, in this case, not measurable. A good suggestion is to put small identical objects, such as paper clips, washers, or cubes in the second pan until balance is achieved. Then the children can see that one object is balanced by, or has the same weight as, for example, 11 cubes. (See Figure 4.) If the children do not think of this, suggest the method and demonstrate it. If a child does suggest it, let him demonstrate it. Then ask the children to compare the forces in each pan by making a statement such as, "This object weighs the same as 10 paper clips.

Separate the children into groups, and give each group a balance, 20 cubes, and an identical collection of items to be weighed (see *Materials*). The collection that you give each group is identical to the one used in *Activity 2.* Remind the children that they arranged the objects from lightest to heaviest in *Activity 2* by comparing them two at a time. Now have them count the number of cubes needed to balance each object. Ask them to record the number of

FIGURE 4

cubes on paper or on the chalkboard. Next to each numeral, you might have the children draw the object or, if they are able, write the name of the object. (See Figure 5.) You may want the children to record their answers on the response sheet *Making Comparisons, Balancing 2*.

Have the children compare the number of cubes required to balance each of the objects in any way that seems suitable. Since the objects are identical, the results of each group should agree closely. Ask the groups to try to account for any discrepancies. Then have them arrange the objects in order from the lightest to the heaviest. Ask the children if their new ordering agrees with the ordering they made in *Activity 2*. Again, try to get the children to account for any discrepancies.

If the children wish to weigh objects in terms of another arbitrary unit of weight, paper clips can be used in place of the cubes.

Materials

Equal-arm balances, 5, each consisting of a base, balance arm, two balance pans, two pan halters, and two sliding compensators (*Module 26*)
Cubes, 100, 1-cm (*Module 30*)
Small objects to be weighed by each group
- Toy car, 1 (*Module 25*)
- Washer, bolt, screw, slug, and rubber stopper, 1 of each (*Module 26*)
- Cube, 1, 3-cm (*Module 25*)
- Bar magnet, 1 (*Module 27*)
- Hand lens, 1 (*Module 19*)
- Nut, 1, metal (*Module 27*)
- Dropper, 1 (*Module 28*)
- Paper clips, 5 boxes

Making Comparisons, Balancing 2, 2 spirit masters (*Module 26*) (optional)

Pencils, 1 for each child (optional)

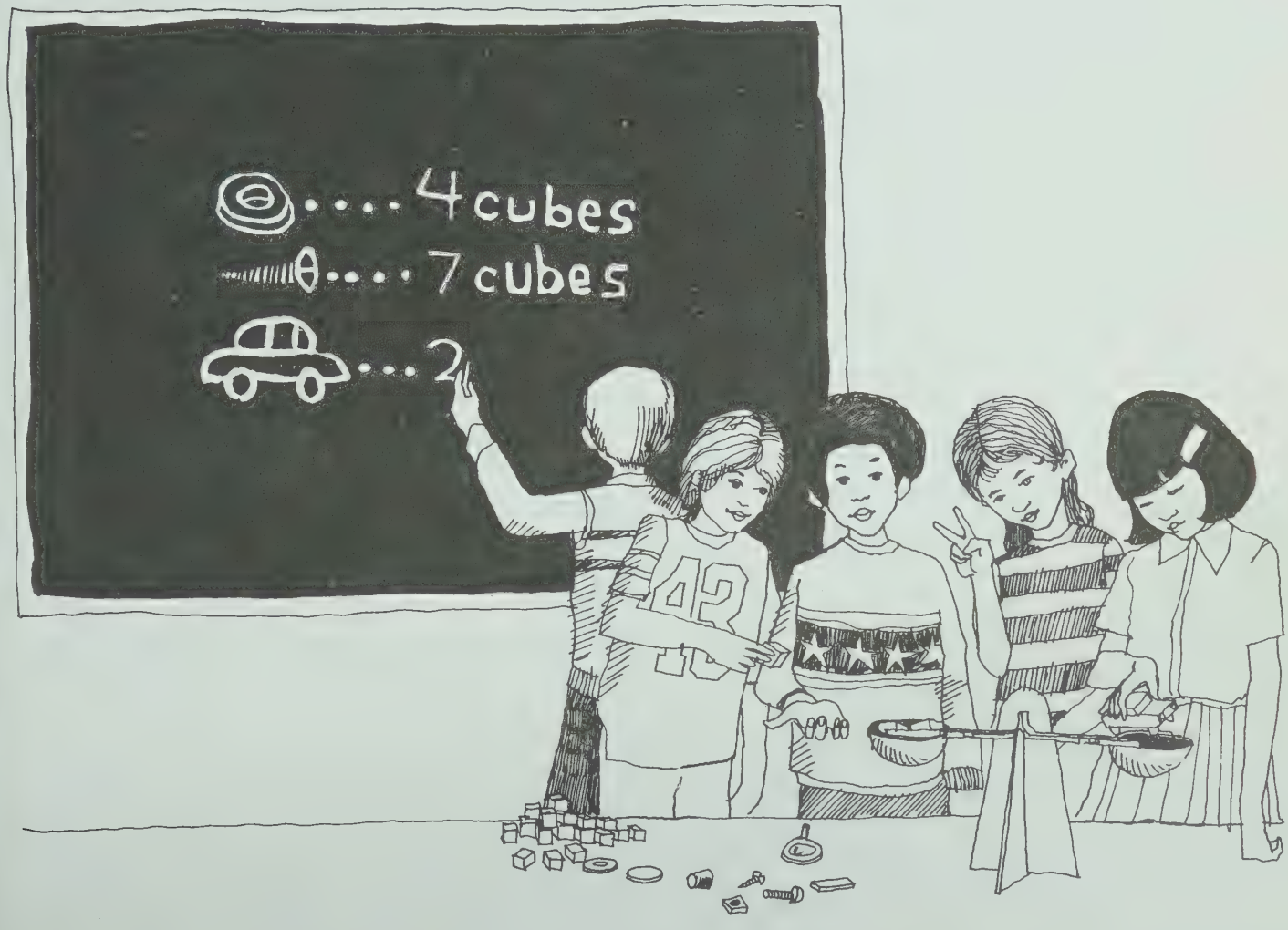


FIGURE 5

Generalizing Experiences

Keep the balances in the room and accessible to the children. Encourage them to experiment with a variety of arbitrary units for comparing objects and for ordering objects on the basis of their weight.

You might suggest that the children construct a "see-saw" balance to be used for comparing the weights of objects that are too large or heavy to be compared by using the balance supplied. Help the children to plan, construct, and use the see-saw balance. It is important that the objects to be compared be located on opposite ends of the see-saw at equal distances from the supplied fulcrum or central support. (See Figure 6.) Three lines could be drawn on the see-saw: one at the center, and two equidistant from it at either end of the board. The line at the center should be located at the fulcrum and the objects to be compared should be placed on the other lines.

With a large see-saw balance two children can compare their own weights. Ask the children to stand at equal distances from the fulcrum. If the lighter child is handed several identical books, one at a time, until the see-saw is balanced (see Figure 7), the weight of the heavier child can be expressed as the same as the weight of the lighter child plus the number of books he or she is holding.

Materials

Equal-arm balances, 5, each consisting of a base, balance arm, two balance pans, two pan halters, and two sliding compensators (*Module 26*)
Paper clips, several boxes
Cubes, 100, 1-cm (*Module 30*)
See-saw board, about 3 cm thick and 25 cm wide and 1 m long
Fulcrum, 1 (*Module 26*)
Marking pen, 1, to mark lines on the see-saw
Objects, a variety, to be compared using see-saw balance
Books, several, identical

FIGURE 6

FIGURE 7

APPRAISAL

Separate the children into groups, give each group an equal-arm balance, a box of paper clips, and one object, and ask the children to find how many paper clips are required to balance this object. They should make statements such as, "This object weighs the same as _ _ _ paper clips."

Replace the first object with another that is slightly heavier. Then ask the children to find out how many paper clips are needed to balance the second object.

Ask the children to tell you on the basis of their measurements which of the two objects is the heavier. Return the first object to them so they can verify their conclusions by putting one object on each pan of the balance.

Ask the children to predict how many paper clips they should add to the pan holding the lighter object so the two forces will balance. They might do this by finding the difference between the number of paper clips they used to balance the first object, and the number used to balance the second object. Have them add the predicted number of paper clips to the pan holding the lighter object; this should restore a balance and verify their predictions.

Materials

Equal-arm balances, 5, each consisting of a base, balance arm, two balance pans, two pan halters, and two sliding compensators (*Module 26*)
Paper clips, 1 box for each group
Objects, 2 for each group, one slightly heavier than the other

COMPETENCY MEASURE

Give the child three balls: one of plastic, one hollow rubber, and one solid rubber. The balls should be of approximately the same diameter, but have different weights.

TASK 1 (Objective 1): Say to the child, **Order these from lightest to heaviest by lifting them.** The child should correctly order the balls from lightest to heaviest.

TASK 2 (Objective 1): Give the child a balance and say, **Show that your ordering is correct by using the equal-arm balance.** The child should use the balance properly to compare the weights.

TASK 3 (Objective 2): Give the child a book and a pencil and ask, **Which of these is heavier?** After the child identifies the book as the heavier object, ask, **Why is this object (point to the book) heavier than this object (point to the pencil)?** The child should state that the earth-pull on the book is greater than it is on the pencil. If the child responds in some other way, such as by saying that the book is larger than the pencil, say, **Tell me about the earth-pull on each of these objects.** The child should now state that the earth-pull on the book is greater than it is on the pencil.

TASK 4 (Objectives 3, 4): Give the child an open box of paper clips, a balance, and a plastic ball and say, **Use the balance to measure how many paper clips weigh the same as this ball. When you are finished, tell me what you found out.** The child should balance the ball against a number of paper clips, and describe the weight of the ball in terms of the number of paper clips used.

Materials

Ball, 1, plastic foam (*Module 26*)
Ball, 1, hollow rubber (*Module 26*)
Ball, 1, solid rubber (*Module 27*)
Equal-arm balance, 1, consisting of a base, balance arm, two balance pans, two pan halters, and two sliding compensators (*Module 26*)
Paper clips, 1 box

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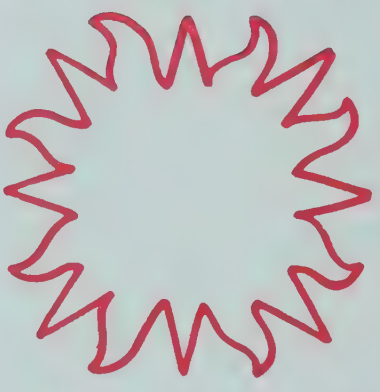

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MODULE

27

Communicating/c

Pushes and Pulls

OBJECTIVES

At the end of this module the child should be able to

1. *NAME* as a force a push or pull that makes an object move.
2. *DEMONSTRATE* a procedure for comparing sizes of pushes or pulls.
3. *IDENTIFY* the heavier of two similar objects as the one that exerts the greater force when both are moving at the same speed.
4. *DEMONSTRATE* a procedure for measuring and recording changes in the position of an object.

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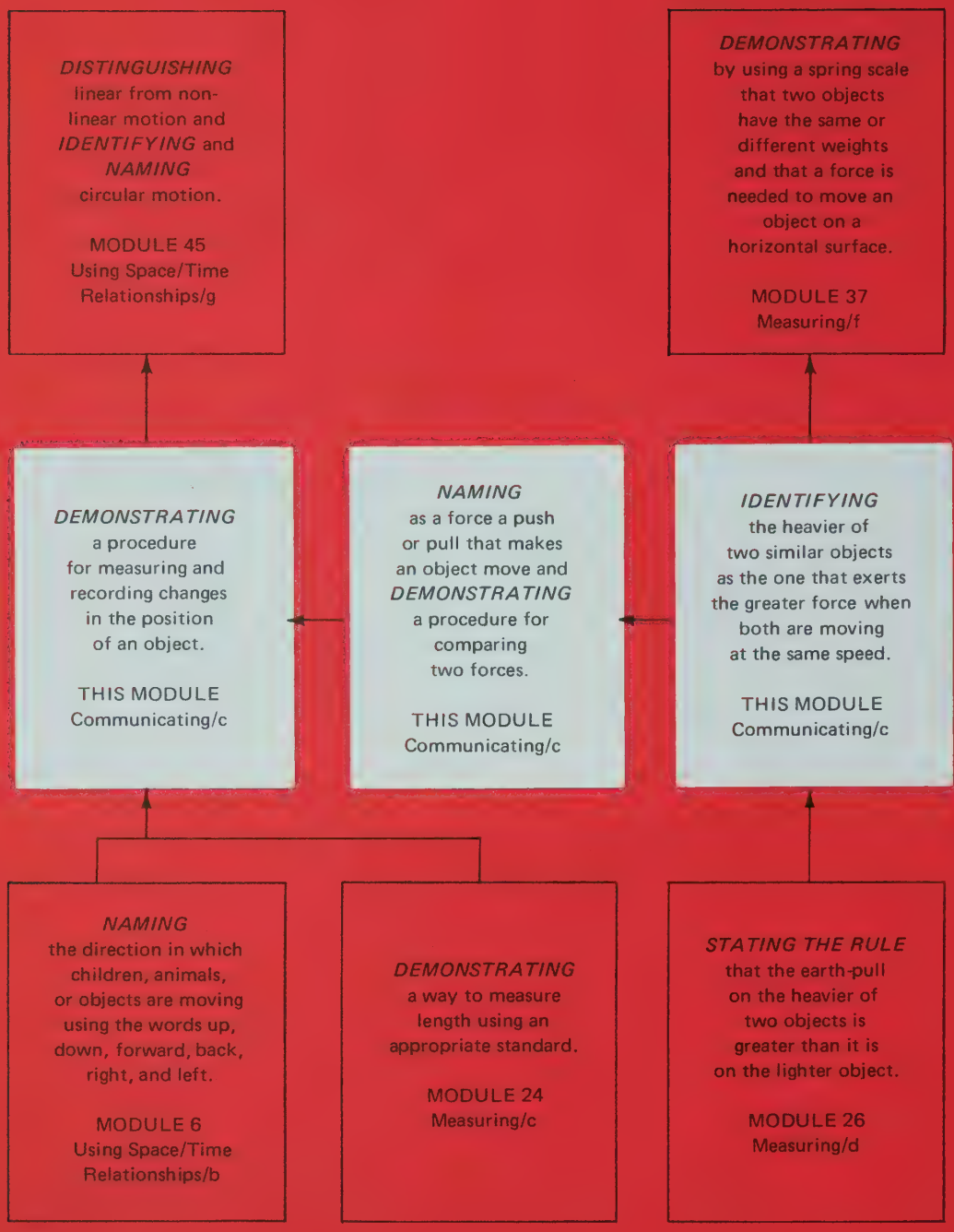
SEQUENCE


DISTINGUISHING linear from non-linear motion and *IDENTIFYING* and *NAMING* circular motion.
MODULE 45 Using Space/Time Relationships/g
DEMONSTRATING by using a spring scale that two objects have the same or different weights and that a force is needed to move an object on a horizontal surface.
MODULE 37 Measuring/f
DEMONSTRATING a procedure for measuring and recording changes in the position of an object.
THIS MODULE Communicating/c
NAMING as a force a push or pull that makes an object move and *DEMONSTRATING* a procedure for comparing two forces.
THIS MODULE Communicating/c
IDENTIFYING the heavier of two similar objects as the one that exerts the greater force when both are moving at the same speed.
THIS MODULE Communicating/c
NAMING the direction in which children, animals, or objects are moving using the words up, down, forward, back, right, and left.
MODULE 6 Using Space/Time Relationships/b
DEMONSTRATING a way to measure length using an appropriate standard.
MODULE 24 Measuring/c
STATING THE RULE that the earth-pull on the heavier of two objects is greater than it is on the lighter object.
MODULE 26 Measuring/d

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

The concept of force was introduced in *Using a Balance, Measuring d, Module 26*. The force considered in that module was "earth-pull." The children used a balance to investigate "earth-pull;" they found that when the balance beam is level, the forces on each pan are equal.

During this module the concept of force is extended to include the idea that a force is a push or pull, and that force can cause an object to move. Specifically, the children investigate the forces exerted by magnets and rolling objects.

The idea that some forces are larger than others is also introduced. The children compare the sizes of forces exerted by magnets of different strengths and by rolling balls of different weights. In the latter case, the children make comparisons of force by measuring the distance a box moves after it is struck by rolling objects that differ in weight.

Besides giving the children more experience in applying the concept of force, this module also gives them an opportunity to develop further their skill in communicating information by making bar graphs. The children's oral communication skills are also increased as they discuss their findings, especially those shown on their graphs.

If your children are unfamiliar with the idea of "earth-pull," you will need to introduce this idea before beginning this module.

Vocabulary

force	collision
magnet	incline

INSTRUCTIONAL PROCEDURE

Introduction

Divide the children into groups of six. Give each group an equal-arm balance, two paper clips, and a bar magnet.

Have the children place a paper clip in one balance pan. Ask them to explain why the balance pan containing the paper clip goes down. If they do not mention earth-pull in their explanations, you might remind them of their use of this term in *Using a Balance, Module 26*. The children will probably agree that earth-pull is greater on the pan containing the paper clip than on the empty pan.

Next have the groups place an identical paper clip in the empty pan so that the balance arm is again level. Ask the children to explain what happened. They should agree that now the earth-pull on each pan is the same.

Have each group remove the paper clip from one pan, let the balance arm tilt, and then make it level again by pressing down on the empty pan with a finger. Ask the children to explain why the balance arm is level now. After the children have discussed this for a while, they may generate the idea that they are exerting a force (a push down), and that this force is the same size as the earth-pull on the paper clip in the other pan. If this idea does not come from the children, tell them that a force can be a push as well as a pull.

Finally, have the groups put a paper clip in the empty pan so the balance arm is level. Direct the groups to hold the magnet under one pan. (See Figure 1.) Ask the children to explain why the pan moves down. They should agree

FIGURE 1

that if the pan moves down, the magnet must be exerting a force that is pulling down.

Materials

Equal-arm balances, 5, each consisting of a base, balance arm, two balance pans, two pan halters, and two sliding compensators (*Module 26*)
Paper clips, 10, large
Bar magnets, 5, strong (*Module 27*)
(Note: Strong and weak magnets are supplied. Throughout this module, for each activity requiring magnets, select the magnets of appropriate strength.)

Activity 1

Divide the children into groups of three or four. Give each group a magnet and a variety of objects such as those suggested in *Materials*. Ask the groups to find out whether the magnet exerts a force on each of these objects. As the children continue the investigation, suggest that they separate those objects on which the magnet exerts a force from those objects on which it does not. Have them make two separate piles.

After the children have completed this task, ask one group to tell what they found out. Everyone should agree that the magnet did not exert a force on the objects that are not metal, and that the magnet exerted a force on only certain metal objects. If other groups disagree, ask them to repeat their observations.

Give each group a balance pan and a paper clip, and ask the children to classify these two objects as they did the other objects. The magnet will exert a force on the paper clip, but not on the pan.

Ask the children how they think the magnet was able to pull the pan down in their earlier activity (see *Introduction*). The children should explain that the magnet will exert a force on the paper clip through the plastic pan. Suggest that the groups see whether the magnet will exert a force through other objects that it does not exert a force on.

Materials

Bar magnets, 10, strong (*Module 27*)
Objects, a variety including aluminum foil, paper, pencils, steel balls, marbles, iron nails, aluminum nails, and pennies
Balance pans, 10 (*Module 26*)
Paper clips, 10, large

Activity 2

Divide the children into groups of two to four. Give each group two bar magnets that are of the same size, but of different strengths. One magnet should be approximately twice as strong as the other. Also give each group ten or more steel nuts. Suggest to the groups that they see how long a train of nuts they can pull across the table with each of the magnets. (See Figure 2.) Ask them why one magnet can pull a longer train than the other. Everyone should agree that the magnet that can pull the longer train exerts the greater force.

Ask the groups to find out whether the magnet exerts the same force in the middle of the bar as it does on the ends. They might use the train-of-nuts method to find that the magnet exerts greater force at the ends of the bar.

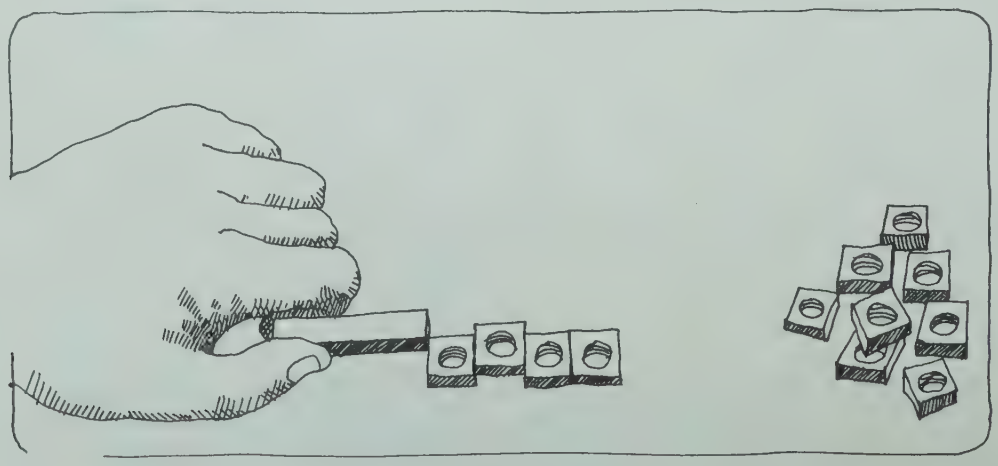

FIGURE 2

If the children continue to be interested in this activity, ask them to find other ways of comparing the strengths of two magnets. Playing tug-of-war with a steel nut, lifting chains of paper clips, and exerting a force on something through several thicknesses of paper are some possibilities.

Materials

Bar magnets, 20, ten each of two different strengths (*Module 27*)
Nuts, 100, steel (*Module 27*)
Paper clips, 1 box
Paper, several sheets

Activity 3

Show the children a hollow rubber ball and ask the children if they can suggest ways in which the ball could exert a force. They may suggest that the ball exerts a force on the floor when it is dropped, on the hand when it is caught, on the balance pan when it is placed in the pan, and so on. Ask whether these forces are like the force of the magnet. After some discussion they should see that the forces caused by the ball are all pushes and that the magnet's force on the nuts, paper clips, and so on is a pull.

Remind the children that they compared the forces of two magnets by counting how many nuts each magnet could pull. Have them now compare the forces of two moving balls by seeing how far each ball can push a box.

Divide the children into groups of three or four. Give each group the following materials: a hollow rubber ball and a solid rubber ball of approximately the same size, a corrugated board, books or blocks, a cardboard box, a metric ruler, and a sheet of graph paper for each child. The children should elevate one end of the board approximately ten centimeters by placing blocks or books under it. A cardboard box should be placed at the bottom of this ramp. The children release the balls, one at a time, at the top of the ramp, and let each ball roll down and hit the box. Have the children observe what happens when each of the two balls, rolling at the same speed, collides with the box.

Ask individual children to state what they observed. They may make statements such as this one: The box moved farther when the solid rubber ball hit it than when the hollow rubber ball hit it. Ask the children which ball exerted a greater force on the box, the heavier ball or the lighter ball. Ask them how much greater the force was. The children should answer that the heavier ball exerted the greater force on the box.

Next have the children try to devise a method for comparing the forces the balls exert on the box. If the children have not decided on a method after a few minutes, suggest that they measure the distance the box moves in centimeters as each ball collides with it. Suggest that they try this several times for each ball. Have each child make a bar graph to show how far the box was moved each time one of the balls collided with it. Have the children color a 2-centimeter square for each 1 centimeter that the box moved. (See Figure 3.) Then together look at the information on the graph and agree on the best measurement for the distance that each ball pushed the box.

This activity may be extended in a number of ways. The children might repeat the activity using a third ball of a

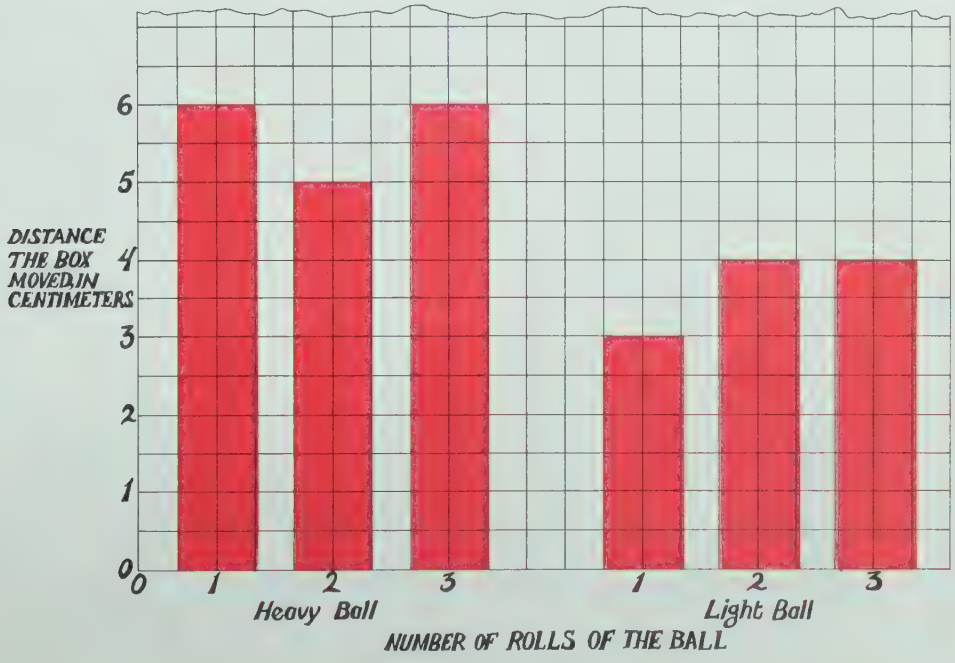

FIGURE 3

weight different from the first two, but of approximately the same size. They might compare the weights of the three balls by using the equal-arm balance and paper clips or washers as units of weight. The children could then repeat the investigation with the ramp and box, and use the information gathered to make another bar graph showing the distance in centimeters that each ball moved the box.

Materials

Balls, 10, hollow rubber (*Module 27*)
Balls, 10, solid rubber (*Module 27*)
Corrugated boards, 1 for each group , about 1 m long
Books or blocks, several, to elevate one end of each board about 10 cm
Cardboard boxes, 1 for each group, to put at bottom of inclined plane, light enough to move when struck by either ball
Ruler, 10, metric (*Module 27*)
Graph Paper, 1 spirit master (*Module 27*)
Balls, several, same size as the rubber balls but of different weight (optional)
Equal-arm balances, 5 (*Module 26*) (optional)
Paper clips, several boxes (optional)

Generalizing Experience

As the occasion arises, discuss situations in which one object collides with another and motion results. Be sure that the children discuss these situations in terms of the forces applied to the static objects. For example, they might discuss the differences between bowling with a bowling ball and bowling with a rubber ball of the same size. Similarly, they might consider what would happen if a rowboat and a steamship, moving at the same speed, each collided with a wharf.

Encourage everyone to be aware of the concept of force in their everyday activities. What pushes and pulls can the children think of? Ask, for example, what is the force that makes a pinwheel spin?

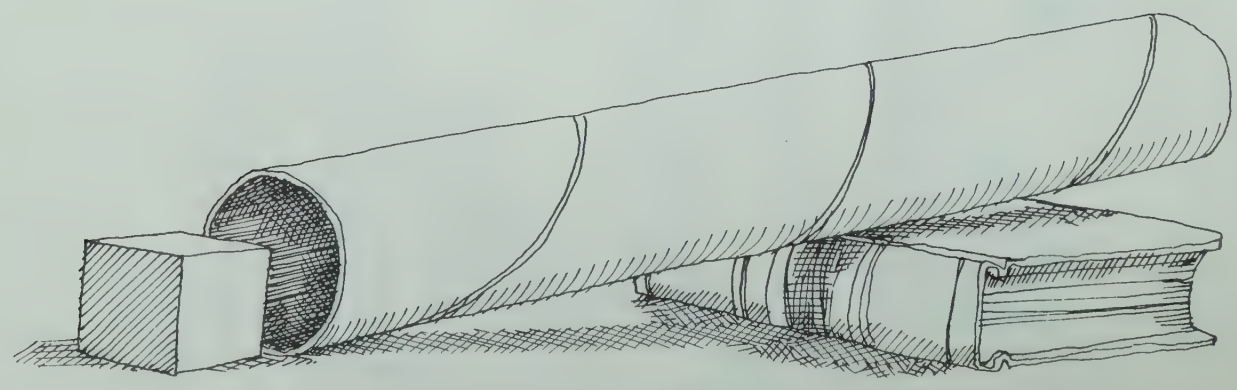

FIGURE 4

APPRAISAL

Ask two children to toss a ball back and forth between them. Ask them what makes the ball move. They may say that their hands push on the ball. If they say this, encourage them to say that their hands "exert a force" instead of "push."

Give small groups of children magnets and steel nuts. Ask them to use the nuts to find out whether the ends of the magnet each exert the same amount of force. The children might make trains out of the nuts as in *Activity 1* and they will probably find that each end pulls the same number of nuts. If the children do obtain this result, they should conclude that the two ends exert the same force. If they find the ends exert different forces, accept their findings and ask them to tell you how they decided one end was stronger than the other.

Show the children two identical coffee cans. Don't let them know that one is empty and the other is full. Put a cardboard box on a table where all the children can see it. Roll first one can and then the other against the box from a distance of about 1 meter. Try to roll the cans at the same speed. Ask the class which can is heavier. They should identify the can that exerts the greater force (pushes the box farther) as the heavier of the two cans.

Ask one or two children to help you measure the distance the box moves when it is struck by each of the cans. Write the distance on the chalkboard. Supply graph paper and ask the children to make bar graphs to record the data.

Materials

Rubber ball, 1, hollow or solid (*Module 27*)
Bar magnets, 10, strong (*Module 27*)
Nuts, 100, steel (*Module 27*)
Coffee cans, 2, with plastic lids, same size and appearance, but one empty and one full
Cardboard box, 1, weight sufficient to be moved slightly when struck by lighter coffee can
Ruler, 1, metric (*Module 27*)
Graph Paper, 1 spirit master (*Module 27*)

COMPETENCY MEASURE

TASK 1 (Objective 1): Put a magnet, a book, and a steel nut or bolt on the table and tell the child to watch what you do. Push the book across the table. Next pull the steel object along the table with the magnet. Ask, What made the book and the nut move? If the child says that your hand and the magnet did, ask, What did my hand do and what did the magnet do? If the child says that your hand pushed and the magnet pulled, ask, What is another name for a push or a pull? The child should say "force."

TASK 2 (Objective 2): Give the child two flexible magnetic strips and ten paper clips. Say, Show me how you can find out whether these magnets are of the same or different strengths. The child should pull rows of paper clips along the table, hang them from the magnetic strips, or in another way demonstrate that the magnets are of the same or different strengths.

TASK 3 (Objective 3): Put a book on the table and rest one end of a cardboard tube on the book. Put a plastic cube at the bottom of the tube. (See Figure 4.) Say, Watch what happens when I roll a sphere through the tube. Roll a plastic sphere down the tube. Now say, Watch what happens when I roll another sphere down the tube. Again, put the plastic cube at the bottom of the tube and roll the glass sphere through the tube. Ask, Which of the two spheres is heavier? The child should identify the sphere that pushes the cube farther as the heavier of the two.

TASK 4 (Objective 4): Put a metric ruler on the table and give the child paper and a pencil. Say, Use the tube to roll the spheres in turn against the cube, and measure and record the changes in position of the cube. The child should follow the instructions, and make and record measurements of the cube's change in position.

Materials

Bar magnet, 1, strong (*Module 27*)
Book, 1
Nut, 1, steel (*Module 27*)
Magnetic strip, 1, to be cut by teacher into two different lengths (*Module 27*)
Paper clips, 10
Cardboard tube, 1, such as a tube from paper towels
Cube, 1, plastic, 3-cm (*Module 25*)
Spheres, 2, one glass and one plastic (*Module 27*)
Paper, 1 sheet for each child
Pencil, 1 for each child
Ruler, 1, metric (*Module 27*)

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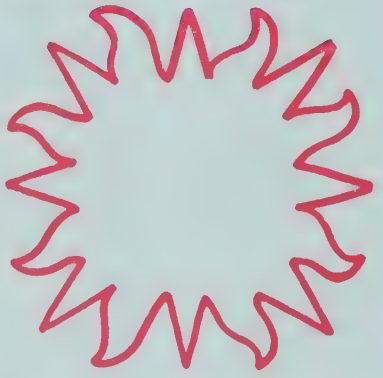

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MODULE
28

Observing/k

Molds and Green Plants

OBJECTIVES

At the end of this module the child should be able to

1. *DESCRIBE* characteristics, such as color, texture, shape, odor, and size, of molds and green plants, or parts of green plants.
2. *DESCRIBE* changes in molds and green plants.
3. *IDENTIFY* conditions that produce changes in molds and green plants, or in parts of green plants.

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SEQUENCE

DESCRIBING the characteristics of a young animal as it grows and changes from one stage to another.
MODULE 31 Communicating/d
IDENTIFYING an animal's response to identified stimuli and *DESCRIBING* a stimulus-response situation in the animal's environment.
MODULE 36 Observing/l
DESCRIBING characteristics and changes in characteristics of molds and green plants, or parts of green plants
THIS MODULE Observing/k
IDENTIFYING conditions that produce changes in molds and green plants, or in parts of green plants.
THIS MODULE Observing/k
DESCRIBING changes in color, shape, size and phase.
MODULE 17 Observing/g
DESCRIBING objects, or changes in objects, after making observations using several of the senses.
MODULES 18, 19 Observing/h, i
DISTINGUISHING between weather conditions from one day to another in comparative terms.
MODULE 21 Observing/j

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RATIONALE

Children are usually fascinated when they have an opportunity to observe how things change. In *Change, Observing g, Module 17,* the children identified certain simple changes in shape, color, size, and phase. In this module, the children will observe and describe some changes that occur in molds and green plants.

Explain to the children that their descriptions of what they observe should be as precise as possible. Color should be described specifically; "the mold is light gray," for example, is more specific than "the mold is gray." To describe the size of an object, the children should compare it to another object; "This light gray colony of mold is as large as a penny." Shapes should be described as being similar to some two-dimensional shape, such as a circle or ellipse.

The whole group should keep simple records so that the children will be able to compare their observations from day to day. Depending on their writing abilities, individual children might be encouraged to keep their own records.

During this module the children learn to identify those conditions that favor growth as well as those that produce various changes in molds and green plants. They observe how mold grows, or fails to grow, in moist and in dry places, in darkness and in light, and on foods and on non-foods. They compare the conditions that stimulate seed germination with those that do not.

Molds belong to the group of living organisms known as fungi; this group also includes mushrooms. Fungi lack chlorophyll, the pigment that enables green plants to manufacture their own food during the process of photosynthesis.

Warmth, darkness, and moisture generally favor mold growth. Molds reproduce by means of tiny particles called spores, which are not true seeds but serve roughly the same function. Spores are formed in spore heads that appear as dust growing on the top of the mold colony; the children may see the spore heads as the mold colonies develop. When the spores have ripened, they scatter; mold spores are found almost everywhere, and they will generate new colonies if the growing conditions are right. One of these necessary conditions is a good medium for the mold to grow on. This can be almost any organic source to which the mold can bond itself.

Some green plants, such as ferns, produce spores, but higher plants reproduce by means of seeds. Each seed contains a tiny embryo plant and one or two cotyledons, or "seed leaves." In order for a seed to germinate, or begin growing, certain environmental factors, such as light, temperature, and moisture, must be favorable. The germinating seed must absorb water, which causes it to swell and break open. The root and leaves of the embryo plant then begin to grow. As part of this module, the children observe how seeds change during the process of germination.

Although the emphasis in this module is on the processes of observing and on describing what is observed, the children also learn some interesting and useful facts about molds and green plants. For example, they will observe that certain fruits and vegetables, such as potatoes, apples, bananas, and eggplants, discolor on standing after being cut. The children learn that the best way to prevent this discoloration is to put a few drops of lemon juice or vinegar on the cut fruit.

Vocabulary

germinate	mung bean
seed leaves	lima bean
mold	fungus (optional)

Advance Preparation

Activity 1 must be started early in the day so that there is enough time to measure the expansion of the seeds after 6 hours of soaking. It is suggested that the children start *Activity 3* early in the week so that during the week the children will be able to observe the changes that take place in the mung beans during the early stages of germination.

Some moldy foods are needed for *Activity 4*. You may be able to use moldy oranges that have been discarded at a grocery store, and you can grow mold on cooked foods such as carrots or cereal. Moistened bread may also be used, but it should be of the home-baked or bakery variety, since most commercially sold breads contain mold-inhibitors. To expose the food to mold spores, place it in the open air for an hour or so. Then cover it tightly with plastic food wrap, and put it in a warm, dark place for a few days.

INSTRUCTIONAL PROCEDURE

Introduction

Before the start of the activity, display lima and mung bean seeds on a table and in full view of the children. If you have them, also display other kinds of seeds. Place each kind of seed in a separate container.

Call the children's attention to the seeds on the table. Ask the children to examine the seeds, and to select a seed to talk about. Call on volunteers to talk about their seeds and encourage them to include statements on color, size, shape, odor, and texture.

Materials

Seeds, 1 package, lima bean (*Module 28*)
Seeds, 1 package, mung bean (*Module 28*)
Seeds, variety of other types (optional)
Containers, 3, 30-ml, clear plastic, with covers (*Module 28*)

Activity 1

Give each child a lima bean seed, and ask what it is. The children are likely to say "bean" or perhaps "seed." Ask what they noticed about the seeds. Then ask for a precise description: size, color, shape, odor, and so on. Record these details on the chalkboard. This information should be quite complete, since the children have already had experience describing seeds as part of the *Introduction*. In addition to the more obvious characteristics, the children may also note a scar where the seed was attached to the pod, and a tiny hole at one end of this scar. (See Figure 1.) If so, record these observations, too.

Divide the children into work groups of three. Give each group 16-20 bean seeds, and a sheet of construction-paper. Ask the children to put their seeds on the construction paper. As they do this, have them arrange the seeds on the construction paper so that they form a rectangle. The seeds must be placed as close together as possible; add a few seeds if necessary to form a rectangle. (See Figure 2.) Have a child draw a rectangle around the arrangement of seeds, and then count the seeds in the rectangle. Emphasize that the seeds just fit into it. Ask how large the rectangle is—that is, how many "bean units." Have the children write a numeral in the rectangle indicating how many "bean units" are needed to cover it. (See Figure 3.) They should cut out the rectangle and save it for use later in the activity.

Have each group of children put their seeds in a 250-milliliter plastic container. They should then fill another similar container half-full with water, and mark the water level on the outside of the container with a felt pen

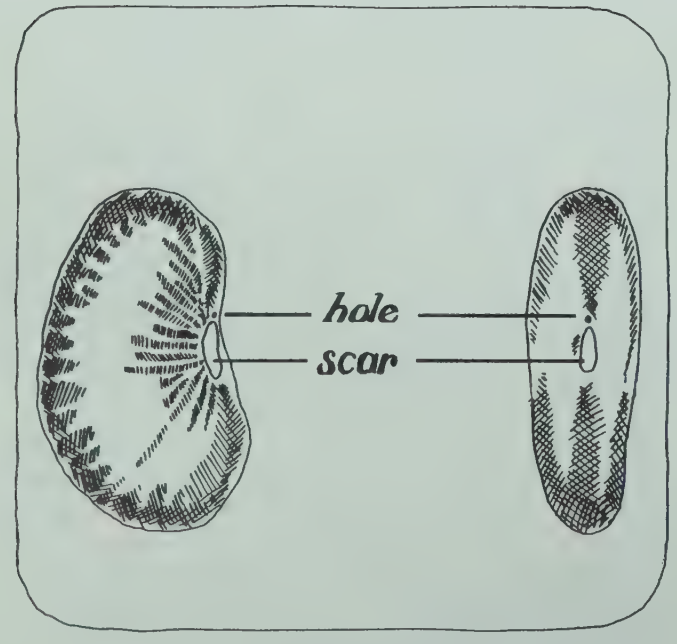

FIGURE 1

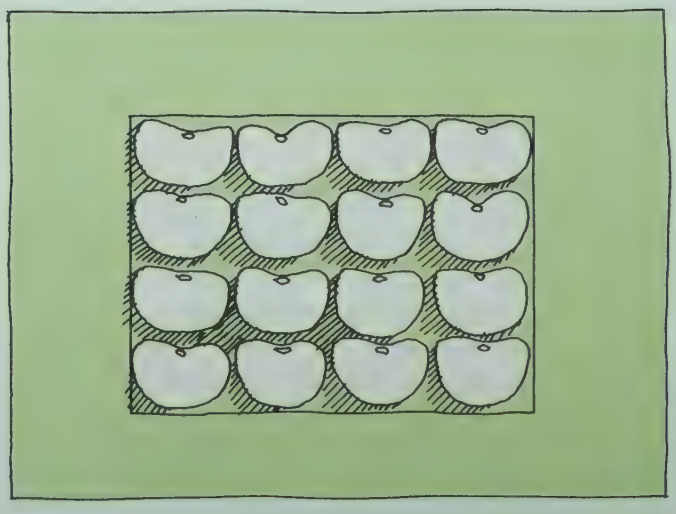

FIGURE 2

or gummed tape. Next, they should pour the measured amount of water into the container of seeds, and then cover the container to prevent evaporation of the water. Have the children record the time when the seeds were covered with water. Tell the children that they will all have a chance to observe the beans again before they go home. Encourage them to look at the beans in the container from time to time during the day.

In the latter part of the afternoon, ask the children to tell what they think has happened to the seeds since they were covered with water. Then instruct the children to pour the water off the seeds and back into the measuring container. Ask the children how this amount of water compares to the amount that was added originally. Ask them where they think the missing water went. Have each group of children arrange their seeds in rectangular form on another sheet of construction paper. Have the children draw a rectangle around the beans, record the number of "bean units" needed to cover the rectangle, cut out the rectangle, and compare it with the first rectangle. (See Figure 3.) When they notice that the second rectangle is larger, ask them what happened to the "bean unit." Have them discuss this. Suggest they use the new "bean unit" to measure the original rectangle. Ask, How many new bean units are needed to cover the first rectangle?

Have the children put the seeds back into their containers and pour the water from the measuring container over the seeds. Again, cover the containers to prevent evaporation of the water. Ask the children what they think will happen to the beans between now and tomorrow morning.

Materials

Seeds, 1 package, lima bean, about 16 seeds for each group (*Module 28*)
Construction paper, 2 sheets for each group
Containers, 20, 250-ml, clear plastic, with covers (*Module 28*)
Marking pen, 1, or gummed tape
Scissors, 1 pair for each group

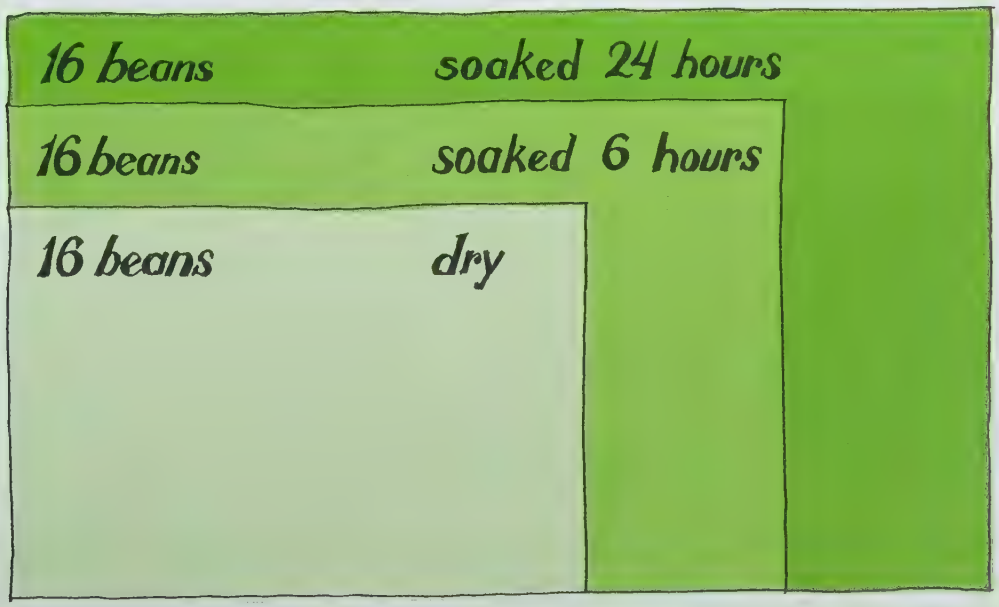

FIGURE 3

Activity 2

On the following morning, have the children again measure the water intake and the size of the beans as before. Depending on the seeds, there may or may not be a further intake of water. If there is, ask the children to comment on the decrease of water and the increase in area of the rectangle and of the "bean unit."

Have each child open one of the soaked seeds. Seeds that have been soaked can be opened easily with the thumbnail. Ask the children to describe what they see. Ask them if they can see what happened to the water. They will probably tell you that they do not see any water inside the seed. The children should notice the two large *seed leaves*, or cotyledons. They may mention that these seed leaves do not resemble the green leaves of plants. Some may notice the little plant within the seed; if they don't, point it out to them. (See Figure 4.)

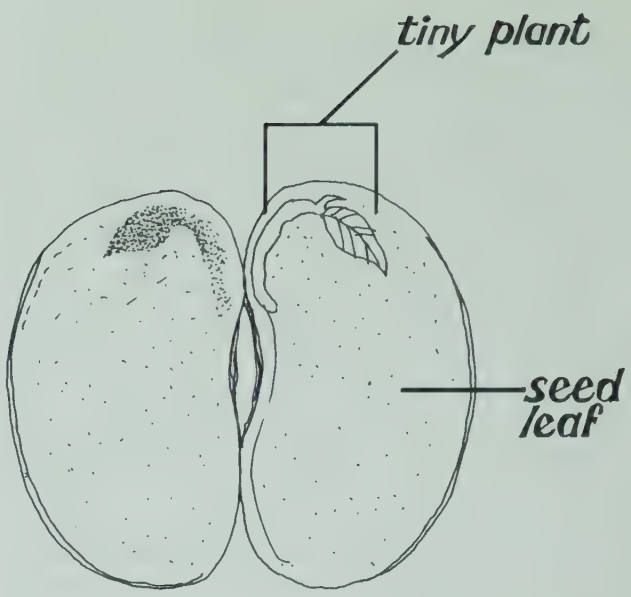

FIGURE 4

Materials

Same as for *Activity 1*

Activity 3

Lima beans germinate slowly, so mung beans will be used in this activity. Mung beans take only 3 to 4 days to germinate, so plan to begin this activity early in the week. If the seeds are soaked in water early in the day, the children will be able to observe the seeds swell and the seed coats break before the day is over.

Divide the children into groups of three. Give each group two 250-milliliter plastic containers with covers, ten mung beans, and a dropper. Ask the children to examine the seeds and to notice their color, size, shape, and texture. Encourage them to talk freely about their observations and to keep their own records; if the latter is not possible, you might write their observations on the chalkboard.

Ask each group to place five mung beans in each of the plastic containers and to use the dropper to add enough water to one of the containers to wet the seeds and to leave a thin layer of water on the bottom of the container. A few drops should be sufficient. The seeds in the other container will remain dry and will serve as a control. Put the covers on the containers, and have each group label its own containers for easy identification. Then put them in a place where it is light and warm, and where the children can observe the seeds. Do not place the containers in direct sunlight. Have the children add a few drops of water to the soaked seeds every day so that they will not dry out.

Before the end of the week, the children should observe the following changes in the seeds.

Day 1: Seed swells; seed coat breaks, and the yellowish-white seed leaves come into view.

Days 2-3: Root appears as a tiny white structure; tips of leaves appear (yellowish green).

Days 3-4: Tiny leaves and stem appear; seed leaves change in color from yellowish white to purplish green; root becomes longer and its tip turns brown.

Days 4-5: Leaves longer, with the space between them wider; color of leaves becomes darker green; stem is longer; seed leaves thinner and purplish brown.

Days 5-6: Stem has grown beyond the seed leaves; leaves are longer and wider; seed leaves are very thin, brown in color, but still intact; root is longer and is turning brown. The seed has now germinated into a green living plant with root, stem, and leaves.

Have the children discuss the changes that they observed. They should mention color changes in the root, leaves, and stem. The seed leaves, too, change color: from yellowish white, to purplish green, to purplish brown, and finally to brown. The children should also describe the changes in size that took place in the seed leaves, leaves, stem, and root.

When they compare the seeds that did not receive any water with the seeds that received enough water, the children should realize that water is necessary for seeds to germinate and grow.

At the end of this activity the children may want to plant the seedlings in soil. This is an interesting activity, and children should be encouraged to do this. It must be done carefully, for the young plants are easily damaged.

Since this activity lasts for several days, the children could start observing changes in molds (*Activities 4* and *5*) while they are observing the growth of seedlings.

Materials

Seeds, 1 package, mung beans
Containers, 20, 250-ml, with covers (*Module 28*)
Droppers, 10 (*Module 28*)
Milk cartons, 1 for each child, or similar container for planting seedlings (optional)
Soil, about 15 liters, for planting seedlings (optional)

Activity 4

Start this activity by placing several 250-milliliter containers of moldy food in a place where the children can observe them individually or in small groups. After all of the children have had a chance to look at the molds, ask each group to describe what they have seen. If no one uses the word, tell them that the things growing on the food are called *molds.*

To begin a mold garden for the class, ask a child to tear a leaf into small pieces, and to put these pieces into a 2-liter container. Another child can add a thin layer of garden soil, approximately 1 centimeter deep, and mix it with the leaves. Other children should put several food and non-food materials into the container. You may use the items in *Materials* or substitute other items if you prefer. One sample of each different kind of material should make an interesting selection. Space the items well apart to allow room for the mold to grow.

Have a child sprinkle, but not soak, the garden with water. Then put a cover on the container. Discuss with the class the role of the water and the cover. The children should realize that the cover helps to contain both the moisture essential for growth, and the odors that develop.

Divide the class into groups of four, and have each group set up its own small mold garden. Small pieces of material should be used; see *Materials* for suggestions. Recommend that each group put at least one non-food object in its mold garden.

It might be a good idea for each group to use different food items, so that the children can see whether the same kind of mold grows on different materials. Have each group put an identifying mark on its garden. Cover each container and put all the gardens in a warm, dark place. Have each group check the gardens daily. When mold growth can be seen, go on to *Activity 5.*

Materials

Containers, 12, 250-ml, with covers; use 3 or 4 for early display of moldy food (*Module 28*)
Leaves, 2 or 3
Container, 1, 2-liter, to hold mold garden (*Module 28*)
Soil, 1 liter
Food items, several, such as orange rind, peach, rolls, leather
Non-food items, several, such as chalk, paper, pencils, steel nails

Activity 5

Discuss with the children the observable characteristics of the various molds, such as color, shape, odor, and size. Call the children's attention to the chalk, nails, and other non-food items. Let the children discuss the similarities and differences among the substances on which molds grow and those on which they do not. In discussing the differences, introduce the idea that molds need food to grow.

Encourage the children to describe the molds; they should include statements about color, size, shape, texture, and odor. Students should also identify the material on which molds grow best. Each group should compare its mold garden with those of other groups.

At the end of the first inspection, ask the class to choose one particularly interesting mold growth for special attention. The children ought to keep a simple record of each observation they make. The format for this record should include verbal and pictorial descriptions of the mold's color, size, shape, and so forth. The class as a group might dictate a record that you could write on chart paper. For example,

The mold is a gray-blue.
It is as small as the head of a thumbtack.
It is almost like a circle.
Our garden is really growing.
The smell is getting worse.

Have the children make the pictorial descriptions by making penciled outline drawings of the materials the mold is growing on and use crayons to draw on it the shape, size, and color of the mold. They should do this for several days, dating each drawing. At intervals, ask the children to use the information from their drawings to describe the growth of their mold colonies.

Materials

Chart paper, 1, to record observations of molds
Drawing paper, 1 sheet for each child
Crayons, 1 box for each child

Activity 6 (Optional)

Encourage children who become quite interested in the life and growth of the molds to try to find out if molds will grow in the light. Point out that their mold gardens have been grown in the dark, and ask the children how they can find out whether the mold gardens will grow in light. To do this, they will have to set up two gardens, one in a dark place, and the other in a light place. Then the children can compare the rates and duration of growth.

The children might also compare differences in the gardens grown with or without soil, grown in closed or open containers, or grown in cool or warm places. Encourage the children to suggest other comparisons that might be made.

Materials

Mold gardens, 2 or more

Activity 7 (Optional)

Introduce the children to the fascinating story of the parasol ants, which are found in some of the world's warmer regions. These ants carry bits of leaves in their mouths as they march to their nests. The leaves, resembling parasols over the marching ants, are used to fertilize underground fungus gardens. Thus, these ants might be called "fungus farmers."

This subject is treated in the book, *Weird and Wonderful Ants*, by Poole, Lynn, and Gray, Ivan Obolensky, Inc., New York, 1961, pages 77-86.

Generalizing Experiences

1. Ask the children to look for molds outside the school. If anyone finds a mold of a color different from any the children have grown, ask the child to bring it to school so the rest of the children can see it.

2. Give each group a dropper, a 120-milliliter container with some lemon juice or vinegar in it, and several pieces of newly cut apples, bananas, potatoes, or eggplants. Let the children put a few drops of lemon juice or vinegar on several pieces of cut fruit; be sure they leave a few pieces untreated. Tell the children to observe what happens to the cut pieces of fruit. They should notice that cut fruits often become discolored on standing in air. Lemon juice or vinegar often prevent this.

Encourage the children to talk freely about their observations and to state the changes that they see. Have them compare the pieces of fruit to which vinegar or lemon juice was added with the pieces that were not treated.

3. Some imitation limeade and grapeade powders contain coloring substances that undergo interesting color changes when they dissolve in water. Children might describe the color changes they observe when water is added a drop at a time to a small amount of the powder.

Materials

Molds, various, brought in by children
Dropper, 1 (*Module 28*)
Container, 1, 120-ml, clear plastic (*Module 17*)
Fruit and vegetables, several pieces cut up, such as apples, bananas, potatoes, or eggplants
Vinegar, 1 bottle (*Module 17*), or lemon juice
Limeade or grapeade, 1 package, powdered

APPRAISAL

Give each child a piece of red cabbage leaf. Have the children observe and describe some of its properties. Next put some pieces of red cabbage into a heat-resistant container with 250 milliliters of water. Place the container on a hotplate, and boil the cabbage and water for about 5 minutes. Let the mixture cool and pour some of the solution into a clear plastic container. Give each child one of the pieces of boiled cabbage and a piece of raw cabbage. Ask the children to describe changes in the pieces of boiled cabbage and in the water in which the cabbage was boiled.

Divide the children into groups of three or four. Give each group two 250-milliliter containers, one containing a teaspoon of baking soda and the other a teaspoon of white vinegar. Have the children add about 50 milliliters of water to each container, and then put a piece of raw and of boiled cabbage in each. Have the children describe the changes they observe.

If there is continued interest in this activity, children might add baking soda to portions of the colored water from the boiled cabbage, and add vinegar to other portions. Encourage the children to describe the changes they observe.

Materials

Cabbage, 1 head, red
Container, 1, glass, heat-resistant (*Module 17*)
Hotplate, 1
Containers, 21, 250-ml, clear plastic with covers (*Module 28*)
Baking soda, 1 container (*Module 17*)
Vinegar, 1 bottle, white (*Module 17*)
Teaspoon, 1

COMPETENCY MEASURE

TASK 1 (Objective 1): Give the child a potato and say, Tell me some of the things you observe about this potato. The child should describe at least three different characteristics, such as size, shape, color, texture, and presence of "eyes." The child may make a term up to describe the "eyes."

TASK 2 (Objective 2): Show the child the picture card showing *Aspergillus niger* mold in the white stage and in the black one. Say, These are two pictures of the same mold. This picture (point to the black stage) was taken a few days after this one (point to the white stage). In what ways did the mold change? The child should say that the mold colony got larger and changed from white to black.

TASK 3 (Objective 3): Pour about 10 milliliters of hydrogen peroxide into each of two containers. Put a lima bean seed into the first container and say, Look at this seed and then watch carefully while I do something to another bean seed. Crush the second bean seed under your heel. Put the crushed seed into the second container. After the child has observed the seed for a sufficient time, ask, What do you see now that you did not see when you observed the first seed? The child should say that there are tiny bubbles in the second container. Then ask, What do you think caused the difference? The child should indicate that the bubbles occurred because the seed was crushed.

Materials

Potato, 1 or 2
Picture cards, 1, one illustration of Aspergillus niger mold in black stage and one in white stage (*Module 28*)
Containers, 2, 30-ml, clear plastic (*Module 28*)
Hydrogen peroxide, about 20 ml
Lima bean seeds, 2 (*Module 28*)

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28 Observing/k

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MODULE
29

Using Space/Time Relationships/e

Shadows

OBJECTIVES

At the end of this module the child should be able to

1. *IDENTIFY* a three-dimensional object from its two-dimensional shadows.
2. *IDENTIFY* the two-dimensional shadows of a given three-dimensional object.

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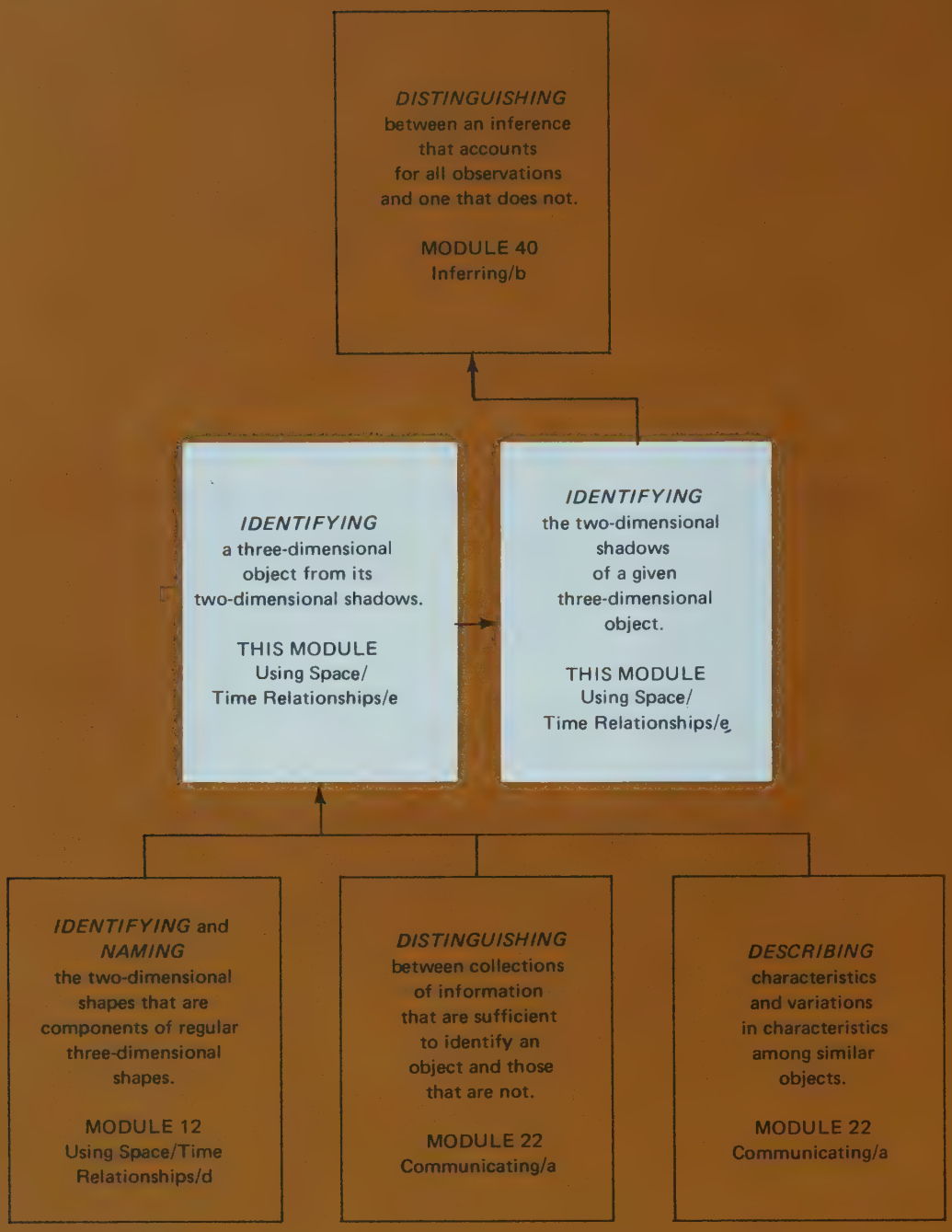
SEQUENCE


DISTINGUISHING between an inference that accounts for all observations and one that does not.
MODULE 40 Inferring/b
IDENTIFYING a three-dimensional object from its two-dimensional shadows.
THIS MODULE Using Space/ Time Relationships/e
IDENTIFYING the two-dimensional shadows of a given three-dimensional object.
THIS MODULE Using Space/ Time Relationships/e
IDENTIFYING and *NAMING* the two-dimensional shapes that are components of regular three-dimensional shapes.
MODULE 12 Using Space/Time Relationships/d
DISTINGUISHING between collections of information that are sufficient to identify an object and those that are not.
MODULE 22 Communicating/a
DESCRIBING characteristics and variations in characteristics among similar objects.
MODULE 22 Communicating/a

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II**, is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.
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RATIONALE

The purpose of this module is to help children recognize the relationship between two- and three-dimensional geometric shapes. They observe these relationships by comparing the shadows cast by the geometric shapes. In previous modules that introduced three-dimensional shapes and objects, the children identified objects by touch and/or sight. However, such close and detailed examination is often not possible. Consequently, in this module the children begin to extend the ability to identify three-dimensional shapes by interpreting their various shadows.

In our daily activities, the ability to visualize in three dimensions is almost essential. This ability plays an important role in our appreciation of art and in many creative efforts. Engineering and manufacturing tasks require this ability, and in some branches of science, such as biology, geology, cartography, and crystallography, this skill is used in highly specialized ways.

The activities in this module provide experience both in predicting the two-dimensional shadows cast by three-dimensional objects and in inferring the shapes of three-dimensional objects from their two-dimensional shadows. The activities can be adapted for children of different abilities and backgrounds by selecting geometric shapes that are suitable. The children will come to understand that an object is not always recognizable from only one shadow. Often more than two shadows are needed for one to infer the shape of the three-dimensional object as is demonstrated in *Activity 5*.

To preclude guessing the three-dimensional shape from relative size, rather than from shadow shape, the diameters of the supplied sphere, disk, cylinder, and cone are approximately the same. Likewise, the length of the rectangular prism is the same as the length of the cylinder; the width of the cube, the same as the diameter of the cylinder; and so on.

The *Generalizing Experience* provides an opportunity to integrate several subject areas. As the children select a subject, write their own plays, and build their own puppets and sets, they draw on the disciplines of social studies, reading, mathematics, and art.

Vocabulary

shadow	parallel
disk	hemisphere
rectangular prism	

INSTRUCTIONAL PROCEDURE

Introduction

Set up a white cotton sheet and a lamp or projector as shown in Figures 1 and 2. Select five children and write their names on the chalkboard. Have these children move behind the sheet, pick up the cardboard numerals on the chairs, and sit behind the sheet where the rest of the children cannot see them.

Pass out paper and have the other children list the numerals "1" through "5" vertically along the left side. Darken the room and ask the child behind the sheet who is holding the numeral "1" to stand near the sheet and in front of the lamp, as shown in Figure 1. Be sure that the child does not identify himself to the others by talking or laughing.

Turn on the lamp. Have the child face the sheet for a short time and then turn so that the children can see the shadow of his profile. Be sure the child holds the numeral so the children can read its shadow. Turn off the lamp. Refer the children who have been observing the shadows to the names written on the board. Tell them to write next to the numeral "1" on their papers the name of the child they think was holding numeral "1."

Repeat this procedure with a second child, a third child, and so on. After the fifth child has finished, have the five children put the numerals on the chairs behind the sheet and join the others.

Next ask the children to say who they think was holding each of the numerals. Ask them to tell how they decided. They may mention identifying features, such as height, type of clothing, hair style, and so on. Discuss how more than one view of each child was helpful in identifying the shadows. When the recorded identifications have been discussed, have the five children get their numerals again and stand in front of the sheet so the children can check their answers.

Materials

Rope or heavy string
Bed sheet, 1, to be used as a projection screen
Paper clamps or clothespins, 3 or 4
Lamp, 1, or projector
Numerals 1 to 5, cardboard (*Module 29*)
Writing paper, 1 sheet for each child
Pencils, 1 for each child

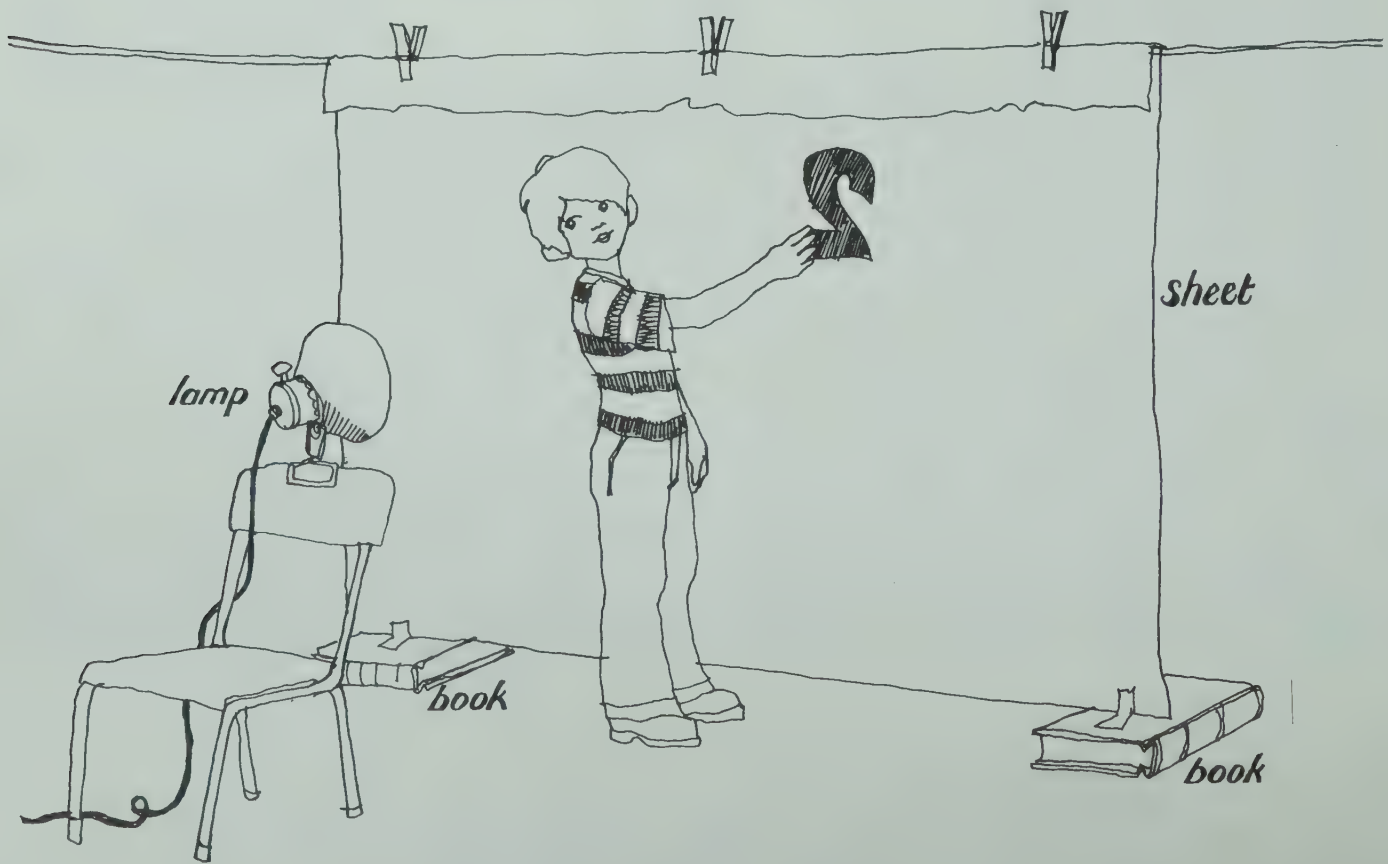

FIGURE 1

FIGURE 2

Activity 1

Place a disk on the shape stand and position it between the children and the screen, so that the children can see both the object and its shadow. (See Figure 3.) The object should be close enough to the screen, and the light source far enough from the screen, so that the shadow is sharp. Now rotate the disk to different positions to show how the shadow changes. Ask a child to describe the shadows.

Place a sphere on another support next to the disk and rotate the sphere. Have the children compare the shadows of the turning disk and the turning sphere. They should note that the sphere always makes a circular shadow but that the disk does not.

Put the cube and the rectangular prism side by side in the light beam. Rotate these shapes. Ask the children to describe the changes in the shadows for each shape.

Have the children handle several three-dimensional objects and infer the shape of the shadows these objects might cast. Some children might make drawings of their inferences. So that the children can verify their inferences, place each object in the light beam. Then rotate each object.

Materials

Shapes, 4, one of each type: disk, sphere, rectangular prism with square end, and cube (*Module 29*) (Note: If you wish to display these shapes in positions other than those allowed by the holes in the shapes, make additional holes with the points of a scissor.)
Shape stand, 1 (*Module 29*)
Support, 1
Projector, 1
Projection screen, 1, or bed sheet
Objects, 4, familiar simple shapes such as paper cups, crayons, and rulers

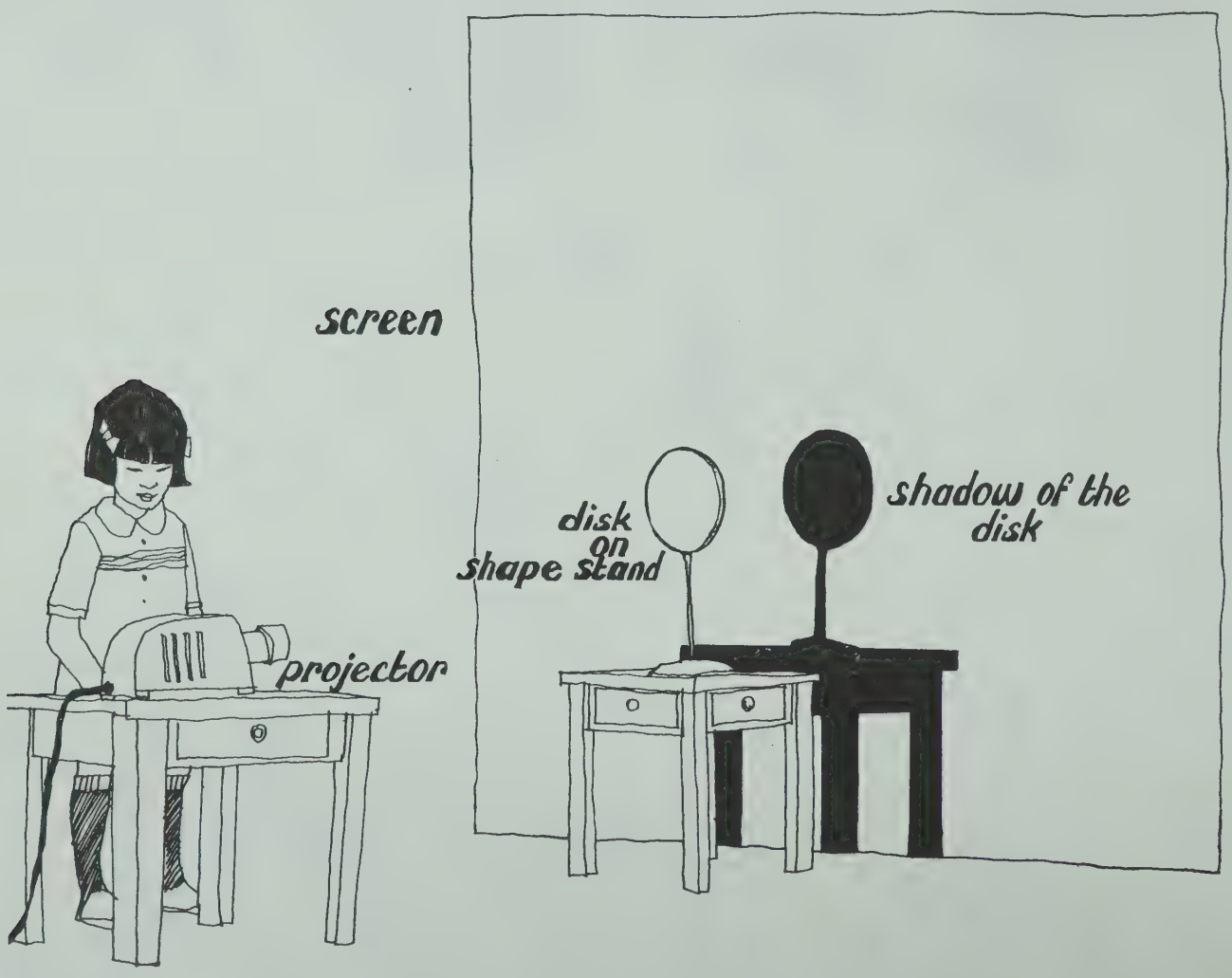

FIGURE 3

Activity 2

Set up the shadow box and the two light sources as shown in Figure 4. Point out the rectangular prism mounted on the shape stand, and put it into the shadow box so that one side is parallel to one of the screens. Then turn on the lights, one at a time. Show the children the two shadows that are visible, and how they can tell that the shape is the rectangular prism. Explain that because two lights produce two shadows of only one shape, the children can see the two views of the shape without moving it.

Put the sphere into the shadow box. The children should notice that *both* shadows are the same.

Put the disk into the box and parallel to one of the screens. Have the children observe both screens. Help the children discover that they can distinguish the sphere from the disk by looking at both shadows.

Repeat this activity with the cube and the rectangular prism. Ask questions such as the following: Can you recognize the rectangular prism, the cube, and the sphere by viewing two shadows of each? Why are two shadows better than one for recognizing solid objects?

Now put the disk, the sphere, and the various other shapes in turn, into the shadow box without allowing the children see which shape you are mounting on the stand. Ask them to infer what object is in the box from its two shadows. First, turn on only one light, and ask them to guess the object. Then turn on the second light to demonstrate why two shadows are needed.

You can also put familiar objects from the room into the shadow box to increase the children's skill and experience in associating two-dimensional shadows with three-dimensional objects.

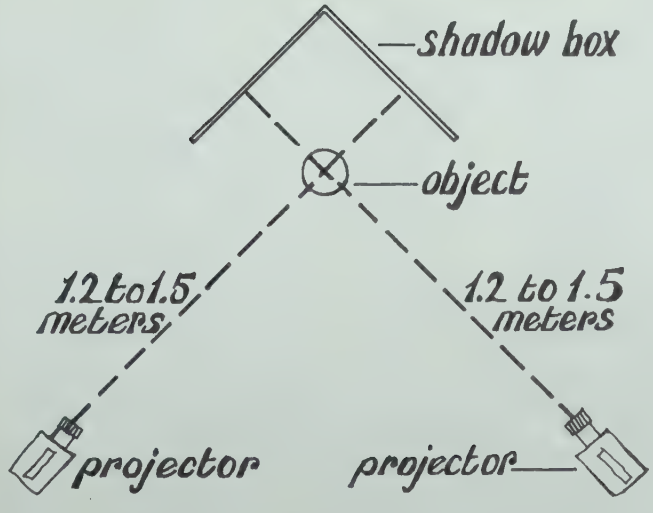

FIGURE 4

To provide some variety, divide the children into two groups and arrange them so that each group sees only one screen. Turn on one light and ask the children in the one group to describe what they see. As shown in Figure 5, they will see circles, triangles, squares, and so on. They should suggest possibilities for the shape of the three-dimensional object casting the shadow they see. Then turn out this light, and turn on the light for the other group. Ask these children what they see. Have the groups discuss their observations together and try to infer the shape of the object.

Materials

Shadow box, 1 (*Module 29*)
Shapes, 11, one of each type: rectangular prism, sphere, disk, cube, cylinder, ellipsoid, pyramid with square base, pyramid with triangular base, hemisphere, isosceles trapezoid, and cone

Shape stand, 1 (*Module 29*)
Objects, several, familiar simple shapes from room
Projectors, 2

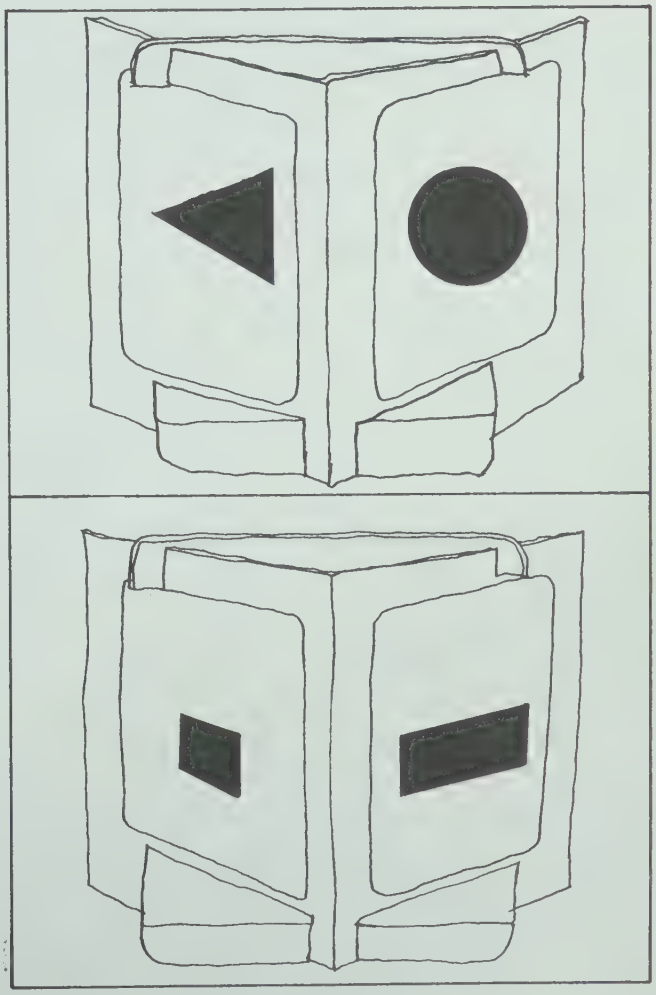

FIGURE 5

Activity 3

Ask the children to bring from home some simple objects concealed in paper bags. The objects might include a ring, cup, toy train, and toy car. Help each child put an object in the shadow box. Ask the other children to infer what the object is from its two shadows. It may be helpful to rotate the objects to several positions inside the box.

You can also conduct this activity as a competition if you divide the children into two groups and have one group try to infer what the other group is projecting.

Materials

Objects, simple familiar shapes brought by each child from home
Shadow box, 1 (*Module 29*)
Shape stand, 1 (*Module 29*)

Activity 4

Show the children a hemisphere. Ask them to draw, on paper, the shadows they would expect if it were put in the shadow box. Then put the hemisphere in the shadow box and compare its shadows with the drawings. Align the object in the box so its shadows will be as similar as possible to those the children have drawn. Try to get the children to identify and name the shape of the two-dimensional shadows.

Materials

Hemisphere, 1 (*Module 29*)
Shadow box, 1 (*Module 29*)
Shape stand, 1 (*Module 29*)

Activity 5 (Optional)

Place a cone and then a pyramid in the shadow box so that each is oriented to throw two triangular shadows. The children can observe that it is impossible to distinguish between the three-dimensional shapes by viewing only two shadows of each shape. Similarly, the children will not be able to distinguish a rectangular prism from a cylinder when each is oriented to throw rectangular shadows. A small can with both ends removed, and a small box with its ends removed, might also be projected to demonstrate the need for three projections at right angles to each other for some identifications.

Materials

Shadow box, 1 (*Module 29*)
Shapes, 4, one of each type: cone, pyramid, rectangular prism, and cylinder (*Module 29*)
Small can and small box, 1 each with ends removed (optional)
Shape stand, 1 (*Module 29*)

Generalizing Experience

Have the children develop a shadow puppet-theater. Use the set-up shown in Figure 6. Suspend a blanket, or any opaque fabric, on a rope line hung approximately 70 centimeters off the floor and in contact with a bed sheet. The puppeteers will be concealed behind the blanket while performing.

It is suggested that the children be divided into groups. Each group may develop its own play or perform a specific task for a class production. Encourage the children to be creative. Have them develop, with little help from you, all the many aspects of a presentation: the different ways that shadows can be cast, the making of the puppets, the writing of the script, and so forth. You may wish to consult one of several children's books on puppets that include examples and directions for building puppets. Allow time for the plays to be presented.

Materials

Bed sheet, 1
Paper clamps or clothespins
Blanket, 1, or other opaque fabric
Rope or heavy string
Projector, 1
Puppets, made by children

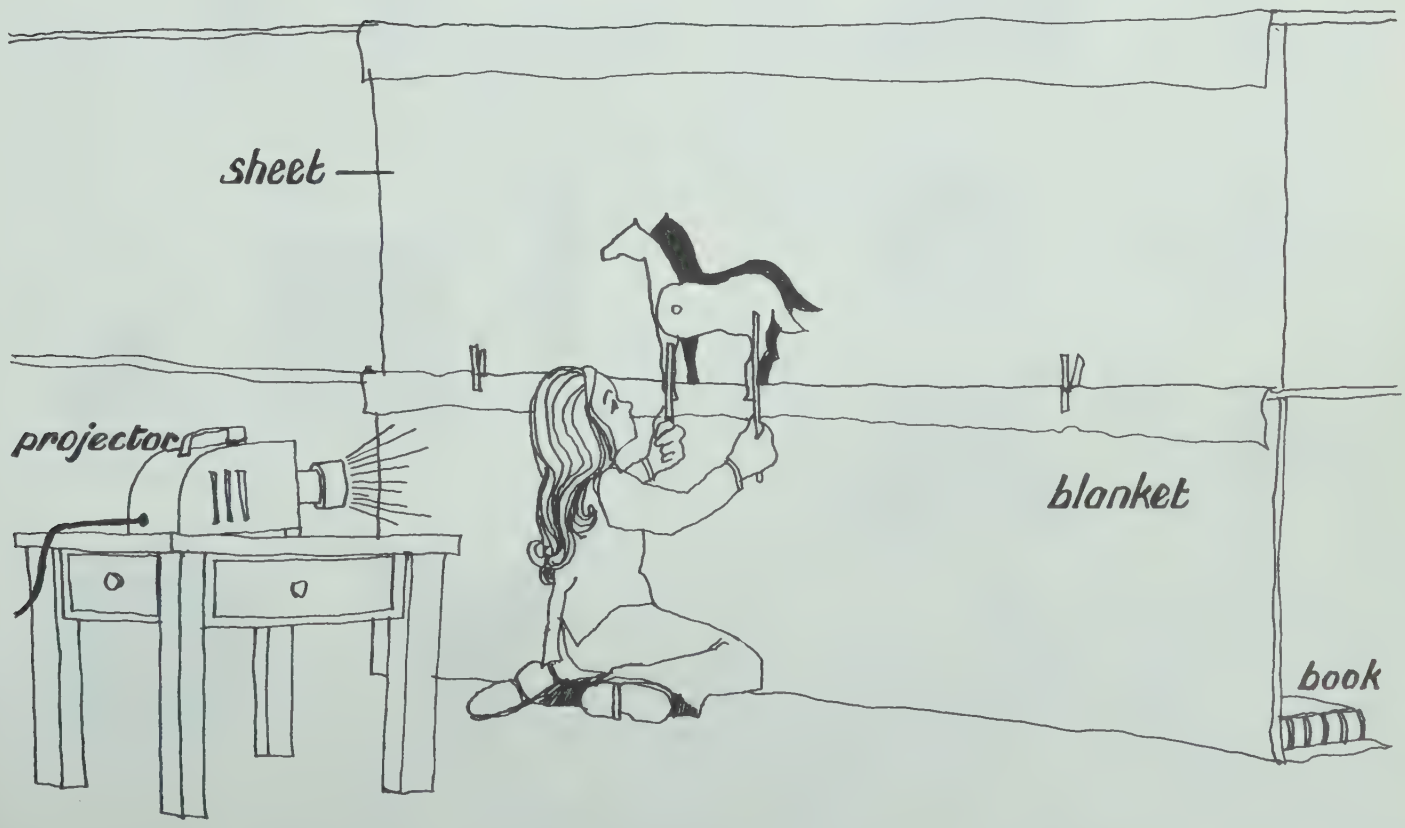

FIGURE 6

APPRAISAL

Give each child a copy of *Circle the Shape* showing outlines of various objects. (See Figure 7.)

1. Put a paper drinking cup on its side in the shadow box. Ask the children to write a "1" on the picture that best represents the shape of the object making these shadows.
2. Put a piece of hollow tubing horizontally in the shadow box. Ask the children to write a "2" on the picture that best represents the shape of the object making these shadows.
3. Put a felt-tipped marking pen in a horizontal position in the shadow box. Ask the children to write a "3" on the picture that best represents the shape of the object making these shadows.

Now give each child a copy of *Circle the Shadow* showing a set of shadows, See Figure 8, and show the children a disk about the size of a silver dollar. Ask them to draw a circle around each shadow that corresponds to the shadows that the disk would make if it were placed in the shadow box.

Materials

Shadow box, 1 (*Module 29*)
Circle the Shape, 1 spirit master, Figure 7 (*Module 29*)
Paper cup, 1
Hollow tube, 1
Marking pen, 1
Disk, 1, about the size of a silver dollar
Circle the Shadow, 1 spirit master, Figure 8 (*Module 29*)

Circle the Shape

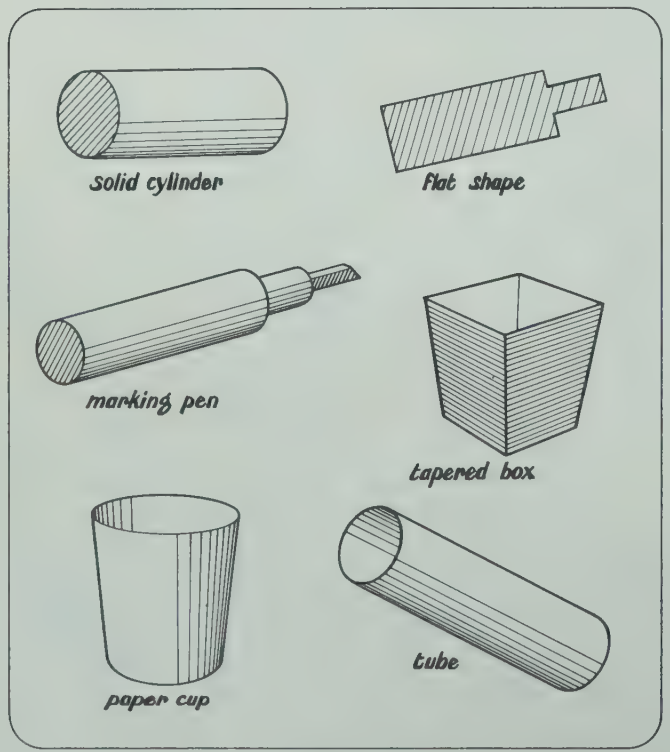

FIGURE 7

Circle the Shadow

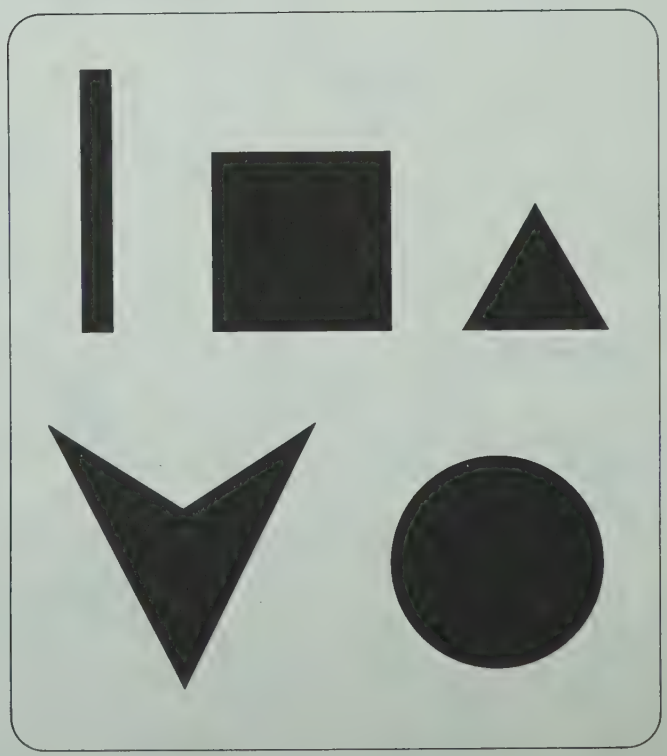

FIGURE 8

COMPETENCY MEASURE

Give the child a sphere, cone, disk, rectangular prism, and cube. Then give him the picture card *Shadow Boxes*, which shows two pairs of shadows made when particular objects were mounted in the shadow box. (See Figure 9.)

TASK 1 (Objective 1): Say, Look at the first pair of shadows, and choose an object that might have been mounted in the shadow box to give these two shadows. The child should identify the cube.

TASK 2 (Objective 1): Repeat the above instructions for the second pair of shadows. The child should identify the cone.

Remove all the materials used in Tasks 1 and 2. Then give the child the isosceles trapezoid and the picture card *Shadows*. (See Figure 10.)

TASK 3 (Objective 2): Say, These shadows were made when objects were put in the shadow box. Choose the shadows made by the object that I have given you. The child should choose the bottom pair of shadows

Materials

Shapes, 6, one of each type: sphere, cone, disk, rectangular prism with square base, cube, and isosceles trapezoid (*Module 29*)
Shadow Boxes, 1 picture card, Figure 9 (*Module 29*)
Shadows, 1 picture card, Figure 10 (*Module 29*)

Shadow Boxes

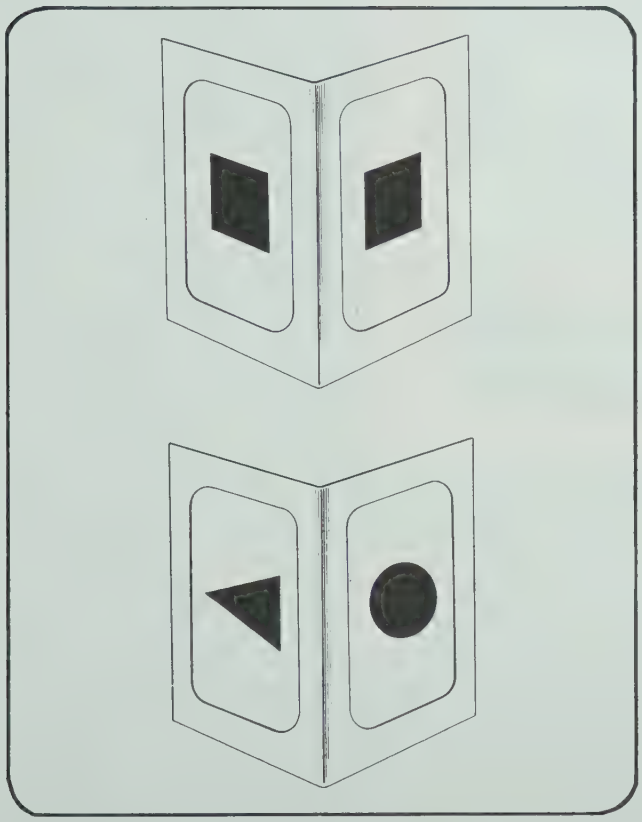

FIGURE 9

Shadows

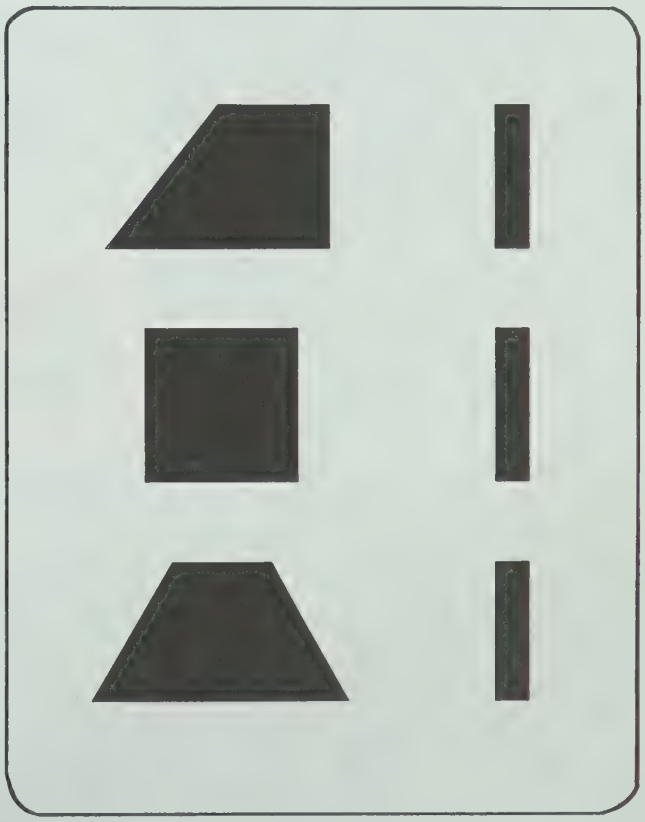

FIGURE 10

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29 Using Space/Time Relationships/e

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SCIENCE... A PROCESS APPROACH II

MODULE

30

Using Numbers/d

Addition Through 99

OBJECTIVES

At the end of this module the child should be able to

1. *CONSTRUCT* a new set of objects by putting two sets of objects together, and *NAME* the number of members in the new set orally or in writing. The number of members in the two sets combined does not exceed *99,* and the members of the two sets are distinct from one another.
2. *NAME* orally the written statement *2 + 3 = 5* as "Two and three are five," "The sum of two and three is five," or "Two and three equals five." And, reversing the process, *CONSTRUCT* the written statement when it is given orally or demonstrated with objects.
3. *NAME* the missing number in a statement like *4 + ? = 7* which has a sum of *9* or less.
4. *DESCRIBE* two-digit numbers as sets of ten and one of the numbers *0* through *9*; for example, *57* is *5* sets of ten and *7,* or *5* tens and *7.*
5. *NAME* the predecessor and successor of each number in any sequence between *0* and *100*; for example, *28* is one less than *29,* and *32* is one more than *31.*
6. *NAME* the sum of any pair of numbers from *0* to *99,* the sum of which does not exceed *99.*
7. *NAME* the sum of repeated addends of the same number with sums not exceeding *99.*

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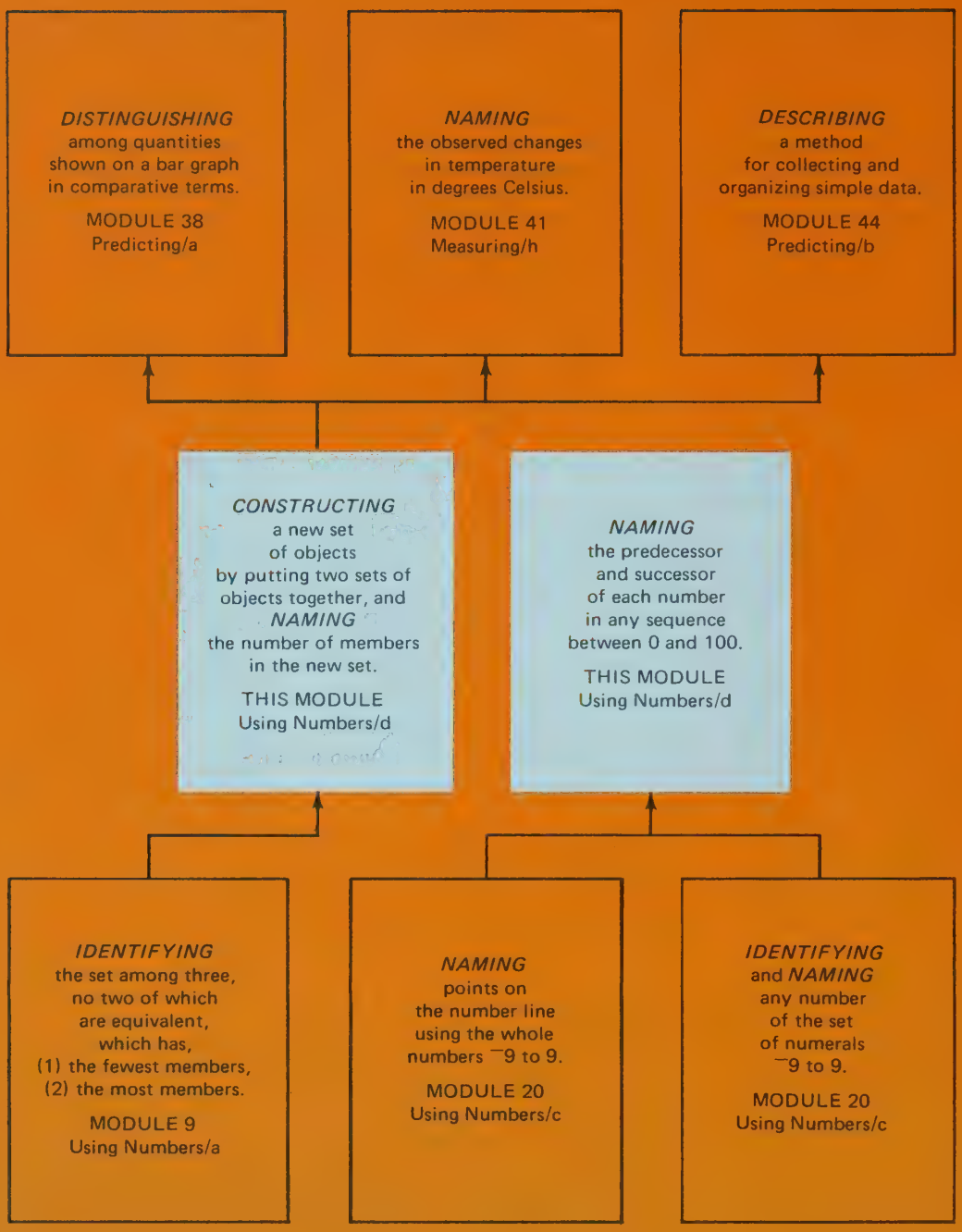
SEQUENCE



The use of this chart, the instruction booklet, other elements of **Science. . .A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173

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RATIONALE

The primary purpose of this module is to teach the children addition. As the children acquire skills in the processes of science, they will soon need to find the sum of two whole numbers. This module is offered for those schools in which the children will not have acquired these skills by this time. In other schools teachers may find this module useful in reinforcing addition skills or in supplementing the materials used in the mathematics program. Depending on the overall program in your school, all, some, or none of the activities may be necessary to achieve the objectives. If you think that none of the activities are necessary for your children, go directly to the *Appraisal* to check the children's competency in the addition of two whole numbers totalling less than *100.*

Mathematics has become the language of precise scientific thought because it helps to express the systematic organization of knowledge. The use of the number sentence in the description of joining operations is an early introduction to this language aspect of mathematics. You should emphasize that *3 + 2, 4 + 1,* and *5* are names for the same number, and that the *equal sign* is used *only* to associate two names for the same number.

This module is a continuation of *Numerals, Order, and Counting, Using Numbers b, Module 13.* In that module, the children learned to count up to twelve, to order the first twelve numbers, and to associate the appropriate written numeral with a given number of members of a set. The order of the numbers was illustrated by associating each number with a set, and then associating its adjacent whole number with a set containing one more or one less member.

Even before children are able to add one-digit whole numbers with facility, they can begin to learn to count to *100* and to read and write two-digit numbers. The purpose of *Activities 6* and *7* is to involve the children in the analysis of what the two-digit number symbols mean. Encourage the children individually to state their analyses in words, and thus apply their developing knowledge of the nature of numbers. Such verbalized analyses should give number symbols a depth of meaning not possible if the shortcut from concrete objects to symbols is taken too soon. The instructional procedure used in this sequence should develop the child's competency to use place value in numeration without the traditional teaching of "one's position" and "ten's position."

In *Activity 8,* the children learn to add two numbers of which the sum is less than *20.* It is suggested that when they are finding sums of 10 or more, they first form a group of ten. This skill is then generalized, in the *Generalizing Experience,* for the sum of two numbers in which the sum is less than *99.* This generalizing step may be too difficult for many children. If so, it can be delayed for several months.

Developed for use with this module is the game *Nine-t-Nine Addition* presented in *Activity 1.* The game may be used to introduce the module or can be used as an alternate activity for almost any activity in the module. The game may also be used as a competency measure either before any teaching has been done or after the module has been taught. Children who complete the game satisfactorily demonstrate that they have acquired many of the behaviors described in the *Objectives.*

One child may play the game, once he has learned the rules, or two or more may play at one time, in which case one child assists the others in following the directions of the game. Thus, the game offers an opportunity both for auto-instruction and for peer teaching.

For children who have not acquired the number skills described in the *Objectives,* the game may be played as many times as necessary and as long as interest continues.

The *Nine-t-Nine Addition and Multiplication* game comprises *Activity 9,* acting as an introduction to multiplication as repeated addition.

Vocabulary

joining sets	number sentence
sum	symbol
equals	multiply

INSTRUCTIONAL PROCEDURE

Introduction

If you decide to introduce the module with the *Nine-t-Nine Addition* game (see *Rationale*), go directly to *Activity 1.* Otherwise, start with this *Introduction* and use *Nine-t-Nine Addition* after the *Introduction* or later in the module as you choose.

To review the concept of sets, give each child nine cubes to manipulate as you ask questions. Ask the children to illustrate the meaning of each of the following phrases: member of a set, the number of members in a set (how many?), an empty set, establishing a one-to-one correspondence between the members of two sets, a set that has fewer members than another set, a set that has more members than another set.

Put the numerals *0* through *9* on a flannel board, or write them on the chalkboard. Ask various children to state the names of the numerals, and then to construct a set of objects that has the number of members given by each name. For example, the child reads "four" and makes an arrangement of four objects.

Ask one child to bring two cubes and another child to bring four cubes to your desk. Then have a third child join

these two sets to make a single set. Have this child tell how many cubes are in the new set. Suggest that the child say something like this: "A set of two members joined to a set of four members makes a set of six members." Have each child join a set of two cubes and a set of four cubes at his desk. Then ask all the children to repeat together what the third child said.

Have the children join more sets at their desks, such as two cubes and five cubes, three cubes and one cube, and so on. Then tell the children that they have been adding numbers, or finding the *sum* of two numbers, and that they will now learn to add many other pairs of numbers.

Materials

Cubes, 270, 1-cm (*Module 30*)
Numerals, 10, felt, 0 to 9 (*Module 30*)

Activity 1

An alternate way of introducing this module is to use the game *Nine-t-Nine Addition* with two to four children at one time. Each game consists of a board, four toy cars, two bridges, 12 ten-tokens, one spinner and one instruction sheet. The *Nine-t-Nine Addition Answer Sheets* are prepared with latent images. When the magic pen is rubbed over the answer box once, the answer will appear.

Directions for the Teacher

Put out the board, the four cars, the two bridges, the ten-tokens, the spinner, and one set of latent-image answer sheets and a magic pen for each player.

Call the attention of the players to the following points on the board: △, □, and the Toll Booths. When the players receive directions from the answer sheet, they will sometimes be sent to these points. Also, call the players' attention to the *Counting Line*, which might help them in their adding.

The players must go around the board three times. Each time they pass a toll booth, they are instructed to take a ten-token. The instructions near the circle at the top right corner of the board direct the players with one or two ten-tokens to go left because they have not gone around the board three times. When a player has gone around three times, instructions near the circle will direct him or her to turn right. Read the players' instructions that follow to at least one child, who can then instruct others.

Directions for the Players

Place the bridges on the board in their marked spaces.
Choose a car, and place it on *Start.*
Spin the arrow on the spinner.
After the arrow stops, move the car the number of blocks shown.
Look at the question in that block.
Pick up the answer sheet printed with the name of the street on which you are driving.
Find the same question on the answer sheet.
Each question on the answer sheet has four boxes underneath it.
Choose the answer that you think is correct.
Rub the magic pen once over that box.
A message will appear to tell you what to do next.
If it says *Yes, spin again,* the answer is correct, and you may spin again on your next turn.
If it says *Try again,* wait until your next turn and try again to answer correctly.
Read all the signs on the board carefully so that your car does not go in the wrong direction.
If there is an arrow like this , you may choose which direction you want to drive.
At each *Toll Booth* take one ten-token.
When you have three ten-tokens you may drive down *Bonus Road* to the *Ice Cream Stand.*
Use the *Counting Line* if you need help.

Materials

Nine-t-Nine Addition, 1 game consisting of one board, four toy cars, two bridges, twelve ten-tokens, one spinner, and one instruction sheet (*Module 30*) (Note: Divide the face of the spinner in half and mark it as shown in Figure 1.)
Nine-t-Nine Addition Answer Sheets, 4 spirit masters (*Module 30*)
Magic pens, 4, image developers (*Module 30*)

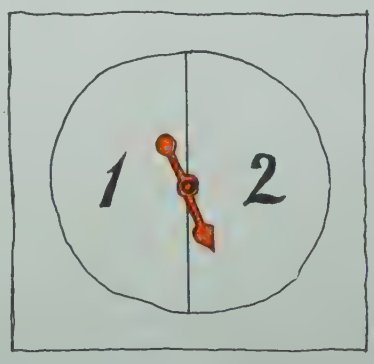

FIGURE 1

Activity 2

Give each of the children nine cubes and ask them to use the cubes as they give oral answers to your questions—sometimes in unison with you and at other times individually.

Ask the children to hold up a set of one cube in their right hands and a set of one cube in their left hands. Then have them place the cubes together while saying something like, "A set of two cubes." Point out that they may also say, "The sum of one and one is two," "One and one are two," or "One and one equals two."

Now ask the children to hold two cubes in their right hands and one cube in their left, and to put these cubes together while saying something like, "A set of three cubes." Again point out that they may also say, "Two and one are three," "The sum of two and one is three," or "A set of two members is joined to a set of one member to make a set of three members." (See the first part of Figure 2.)

Repeat with other numbers, such as *3* and *1*, *4* and *1*, and so on up to *8* and *1* so that the children can explore all such combinations. Then reverse the instructions so that the children join a set of more than one member to a set of one member. (See the second part of Figure 2.) Do not expect to achieve total mastery at this point; rather, treat the activity as an exploratory one.

Now change the pattern to use consecutive numbers as pairs. Start with a set of three cubes and a set of two cubes placed somewhat apart. (See the first part of Figure 3.) Join the two sets of cubes, and ask for a description. (The sum of *3* and *2* equals *5*, or *3* and *2* is *5*).

If the children do not readily make this response, ask if anyone remembers how many objects are in a set of three cubes together with another set of one cube. (Four.) Then ask, "And if one more member were added, that would make a set of how many cubes?" (Five.) (See the second part of Figure 3.)

Repeat the above procedure with a set of four cubes and a set of three cubes, and then with a set of five cubes and a set of four cubes.

Now change the pattern to use zero cubes, the empty set, together with sets containing up to nine cubes.

Using the game described below, you can test the children's ability to use some of the terminology and concepts presented thus far. Many variations of this game are possible. For instance, the children might ask you the questions. Or, you can set up competing teams as for a "spelling bee." The questioning might go like this.

You: I'm thinking of a number that is one more than six. What is the number?

Child: Seven.

You: I'm thinking of a number that is one less than four. What is the number?

Child: Three.

You: I'm holding a collection of candies in my hand. How many members are there in this set of candies? (Hold out your hand to show it is empty.)

Child: Zero.

You: I'm thinking of a number that is less than nine and more than four. (Suppose that you are thinking of seven.)

Child: Is it less than eight?

You: Yes.

Child: Is it more than five?

You: Yes.

Child: Is it less than seven?

You: No.

Child: The number is seven.

Materials

Cubes, 270, 1-cm (*Module 30*)

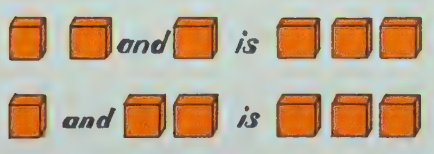

FIGURE 2

FIGURE 3

Activity 3

Show the children a set of five cubes. Ask a child to separate the set into two smaller sets. Then ask the children if they can do this in another way. Encourage different responses until each of these possibilities is mentioned: a set of one member and a set of four members, a set of two members and a set of three members, a set of zero members and a set of five members. Of course, these suggestions are also possible in the reverse order, such as a set of four and a set of one. Repeat this activity for all of the numbers ranging from *0* to *9*.

Ask the children how many members there are in the set obtained by joining a set of six members with a set of two members. Continue this line of questioning using any numbers from the set *0* through *9*. Let the children construct sets of cubes if they need to. Also introduce such sentences as, "*4* and what number are *9*?" or "The sum of *4* and what is *9*?" or "*4* and what are *9*?"

Materials

Cubes, 270, 1-cm (*Module 30*)

Activity 4

In this activity the children learn to use number sentences, such as $1 + 2 = 3$, and to refer to $1 + 2$ and 3 as names for the same number. They should have practice both in reading number sentences and in using symbols to write spoken sentences; for example, they should write the sentence *The sum of 1 and 2 is 3* as $1 + 2 = 3$. Point out that the symbol "=" is used for the word "is" or "equals," and the symbol "+" for the word "and."

As the children work with number sentences like these, they should discover for themselves the unique property of *0*; that is, they should learn that *the sum of any number and zero is that number.* Even more important, they should discover the commutative property of addition: *the order in which two numbers are added does not affect their sum;* for example, $2 + 3 = 3 + 2$.

As the children work with number sentences, display on the chalkboard lists of addition combinations such as those shown in Figure 4. It is through examination of such lists that the *0*-property and the commutative property can be discovered by the children. Remind the children frequently that the lists indicate different names for the same number. For example, $3 + 6$ and 9 are names for the same number, and $3 + 4$ and 7 are names for the same number.

Materials

Writing paper, several sheets for each child
Pencils, 1 for each child

Activity 5

In the number sentence $a + b = c$, where a, b, and c are members of the set of whole numbers *0* through *9*, the children should be able to find the missing number when any two of the three numbers, a, b, and c are given. For some children this will present no difficulty, but for others much practice will be necessary. For the latter group, use of concrete objects will be quite helpful. For example, if the question is $5 + ? = 8$, have the children work in pairs with a set of five cubes and a set of eight cubes. How many cubes should be added to the set of *5* to make the set of *8*? Once the children understand the question, the principal difficulty will have been removed.

For all children, practice with these number sentences should be both oral and written. Write the number sentence $? + 4 = 9$ on the chalkboard. Ask the children to state what the sentence asks and to find the missing number. The child should think, "The sum of what number and *4* is *9*."

You should plan to come back to these number sentences from time to time throughout the year. Vary the examples sometimes by saying, "Find the missing number so that $3 + ?$ and 8 are names for the same number."

Materials

Cubes, 270, 1-cm (*Module 30*)
Writing paper, several sheets for each child
Pencils, 1 for each child

0 + 0 = 0									
1 + 0 = 1	0 + 1 = 1								
2 + 0 = 2	0 + 2 = 2	1 + 1 = 2							
3 + 0 = 3	0 + 3 = 3	1 + 2 = 3	2 + 1 = 3						
4 + 0 = 4	0 + 4 = 4	1 + 3 = 4	3 + 1 = 4	2 + 2 = 4					
5 + 0 = 5	0 + 5 = 5	1 + 4 = 5	4 + 1 = 5	2 + 3 = 5	3 + 2 = 5				
6 + 0 = 6	0 + 6 = 6	1 + 5 = 6	5 + 1 = 6	2 + 4 = 6	4 + 2 = 6	3 + 3 = 6			
7 + 0 = 7	0 + 7 = 7	1 + 6 = 7	6 + 1 = 7	2 + 5 = 7	5 + 2 = 7	3 + 4 = 7	4 + 3 = 7		
8 + 0 = 8	0 + 8 = 8	1 + 7 = 8	7 + 1 = 8	2 + 6 = 8	6 + 2 = 8	3 + 5 = 8	5 + 3 = 8	4 + 4 = 8	
9 + 0 = 9	0 + 9 = 9	1 + 8 = 9	8 + 1 = 9	2 + 7 = 9	7 + 2 = 9	3 + 6 = 9	6 + 3 = 9	4 + 5 = 9	5 + 4 = 9

FIGURE 4

Activity 6

In this activity, the symbol *t* is used for ten before the usual decimal notation is introduced.

Hold up the fingers of both your hands, and have the children count them. Then point out that people have ten fingers, and that early man probably used fingers to count objects by pairing the fingers in one-to-one correspondence with the objects.

Now ask the children how they would count more than ten objects using their fingers. Someone may suggest starting over again, or using toes. What if there are more than twenty objects to be counted? Emphasize the idea of counting over again, time after time, if necessary. Then ask the children how they can keep track of the number of times they have counted over again on their fingers. Someone may suggest making a mark each time, or something equivalent to that. Suggest that they might write a "t" on the chalkboard each time they counted over again.

Show the children eleven small objects (see *Materials*), and ask them to count the objects. As they do, put the first ten in a pile and put the eleventh beside the pile. Count the objects on your fingers, showing that you have "t" objects and one object more. Write this on the board as $t + 1$ objects. Put the set of "t" objects in a small plastic container for handling as a unit.

Then ask a child to count twelve objects in the same way. The child should arrange the objects into a set of ten and a set of two—that is, "t" objects and two objects, or the sum of ten and two, or twelve, which is written $t + 2$. Again, put the set of "t" objects in a small plastic container.

Continue in the same way with thirteen ($t + 3$), fourteen ($t + 4$), and so on until nineteen ($t + 9$). When the children reach ten and ten, point out that ten and ten is two tens, or twenty, which may be written as $t + t$ or $2t$. Continue with twenty-one, which is ten and ten and one, and is written $t + t + 1 = 2t + 1$; twenty-two, $2t + 2$; and so on up to thirty, or $3t$. For $3t$ you would have three plastic containers.

Make a list on the chalkboard of the number names shown in Column A in Figure 5. Have the children fill in Column B on the board, one child following the other to write the next numeral and/or symbol. If you wish, extend the table beyond the range shown.

Now ask the children to look at the table and try to think of shorter names for the numbers above ten. Suggest writing $2t + 4$ as *24*. The numeral *24* stands for two tens and four. Ask the children to tell what numerals to use in other places in the table. For instance, fourteen is $t + 4$, or one ten and four, or *14*.

The children may be curious about the numbers ten and twenty. Ask the class for ideas about how to write these. Write on the board, "Ten is t + ?" and "Twenty is 2t + ?" They may suggest that ten is $1t + 0$, or *10*; twenty is $2t + 0$, or *20*. Ask the children to fill in all of Column C in the table on the board.

Materials

Small objects, 30, such as paper clips, stones, or bean seeds
Containers, 3, 250-ml, plastic (*Module 28*)

A	B	C
zero	0	0
one	1	1
two	2	2
three	3	3
four	4	4
five	5	5
six	6	6
seven	7	7
eight	8	8
nine	9	9
ten	t	10
eleven	t + 1	11
twelve	t + 2	12
thirteen	t + 3	13
fourteen	t + 4	14
fifteen	t + 5	15
sixteen	t + 6	16
seventeen	t + 7	17
eighteen	t + 8	18
nineteen	t + 9	19
twenty	2t	20
twenty-one	2t + 1	21
twenty-two	2t + 2	22
twenty-three	2t + 3	23
twenty-four	2t + 4	24
twenty-five	2t + 5	25

FIGURE 5

Activity 7

Display on a table several sets of objects (see *Materials*). Call the children's attention to one of the sets, and ask how they could make a set of stones, or other small objects, having the same number of objects as that set. (By pairing.) Have one or two children come to the table to demonstrate.

Now ask how many members belong to each of the two sets, the set of objects and the set of stones, for instance. Let a child count them. Ask the children if there is another way to find out the number of members. Could they use the plastic containers? The children will probably suggest putting ten of the stones into a container. If ten or more stones are left, ten of these should be put into another container, and so on, until fewer than ten stones are left. Ask how many stones there are. Since the set of objects matches the set of stones, the children are also counting the set of objects as they count the stones.

Repeat this activity for the other sets of objects on display, comparing the numbers of objects in these sets with the number of stones, for instance, in several containers of ten.

Next ask the children to think of two-digit numbers in terms of what number each comes before and what number each comes after. For example, the number *69* is between *68* and *70; 69* comes before, or is one less than, *70*; and *69* comes after, or is one more than, *68*. Have the children plan and carry out question-and-answer games that reinforce such relationships.

Materials

Sets of objects, several, each having over 10 members, such as one set of cubes (*Module 30*), one of marbles, and one of stones
(Note: At least one set should have over 30 members to avoid counting by inspection alone.)
Containers, 3, 250-ml, plastic (*Module 28*)

Activity 8

At this point the children should be ready to add two numbers to obtain a sum less than 20.

Call the children's attention to a set of eleven books, or other objects, on a table. Ask how many books there are in the set. (The sum of ten and one.) Point out a set of two books on another table. Ask whether anyone knows how many books there would be if the two sets were joined. If a child says, "The sum of ten and three," ask how he or she got that answer. Move one book from the first table to the second table, so there are ten books on one table and the sum of one and two on the other table. Ask the children

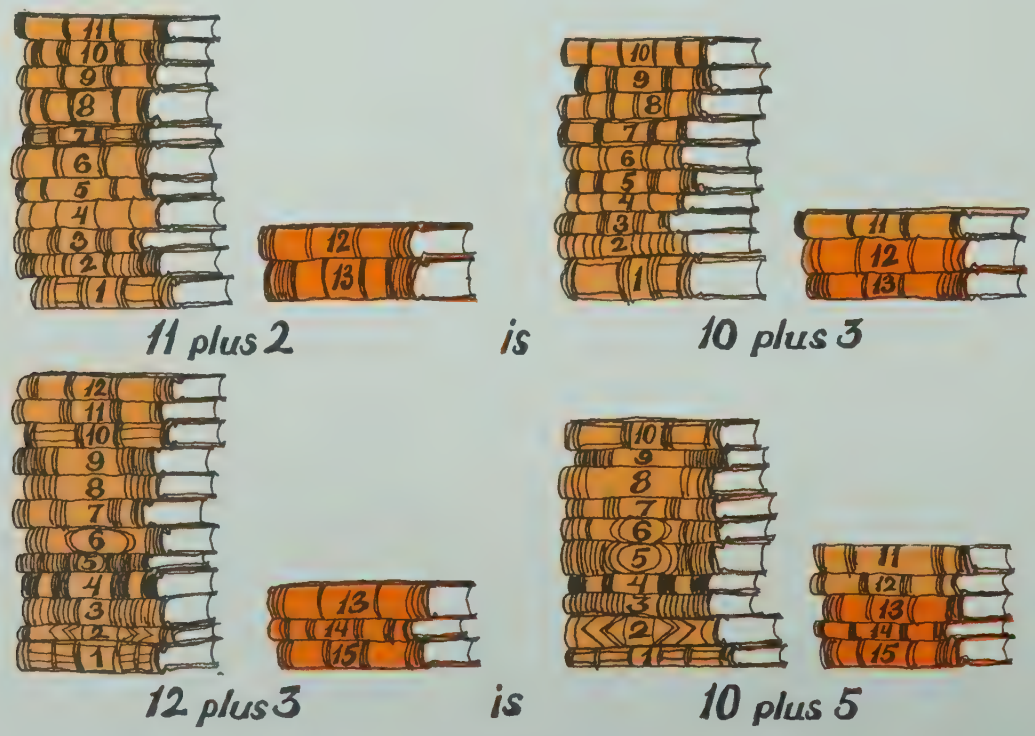

FIGURE 6

what the sum of one and two is. Then say that all together there is the sum of ten and three, or *13*.

Repeat this activity with *11* and *3*, *12* and *3*, and other pairs of numbers the sum of which is less than *20*. (See Figure 6.)

Now show the children two boxes. Tell them that the sum of ten objects and five objects is in one box, and four objects are in the other box. Ask how many objects there are all together. How many objects are five objects and four objects? (Nine.) How many objects are in both boxes? (The sum of ten and nine, or *19*.) Repeat this activity so that most of the combinations are used in which *11* is added to *0* through *8*, *12* is added to *0* through *7*, and so on. (See Figure 7.)

Encourage the children to work in pairs, challenging each other. A conversation between two children might go something like this:

First child: What is the sum of *13* and *6*?

Second child: Well, *13* is the same as *10* and *3*. So, you want to know the sum of *10+3+6*.

First child: Yes, but what is that sum? I will give you one more chance.

Second child: Well, *3 + 6 = 9*, so the sum is *10* and *9*.

First child: No, you do not answer what I ask. You should know that the sum of *13* and *6* is *19*.

Second child: That is what I said, *10* and *9*. Everyone knows that is *19*. When I say your first name is John, and your last name is Jones, do I have to say your name is John Jones?

First child: What does my name have to do with it? Let's have the teacher settle it.

The teacher replies that both *19* and *10 + 9* are names for the sum of *13* and *6* and that we usually say *19* because it is shorter to write and say.

Let those children who can add larger numbers go ahead at their own speed, furnishing them special practice examples as needed. The emphasis in this activity is on addition by grouping by tens, the process demonstrated by the two diagrams in Figures 6 and 7, which differ only in the form chosen for representation. It is not proposed that you have the children use such diagrams. However, you can have the children use objects, such as cubes, first and then the diagrams if the diagrams will help the children to group by tens.

Even though your children may be able to add with a reasonable degree of accuracy, they may never have thought of adding in terms of grouping by tens, so it will be desirable for them to do addition in this way.

Materials

Objects, 19, such as books
Boxes, 2
Cubes, 270, 1-cm (*Module 30*)

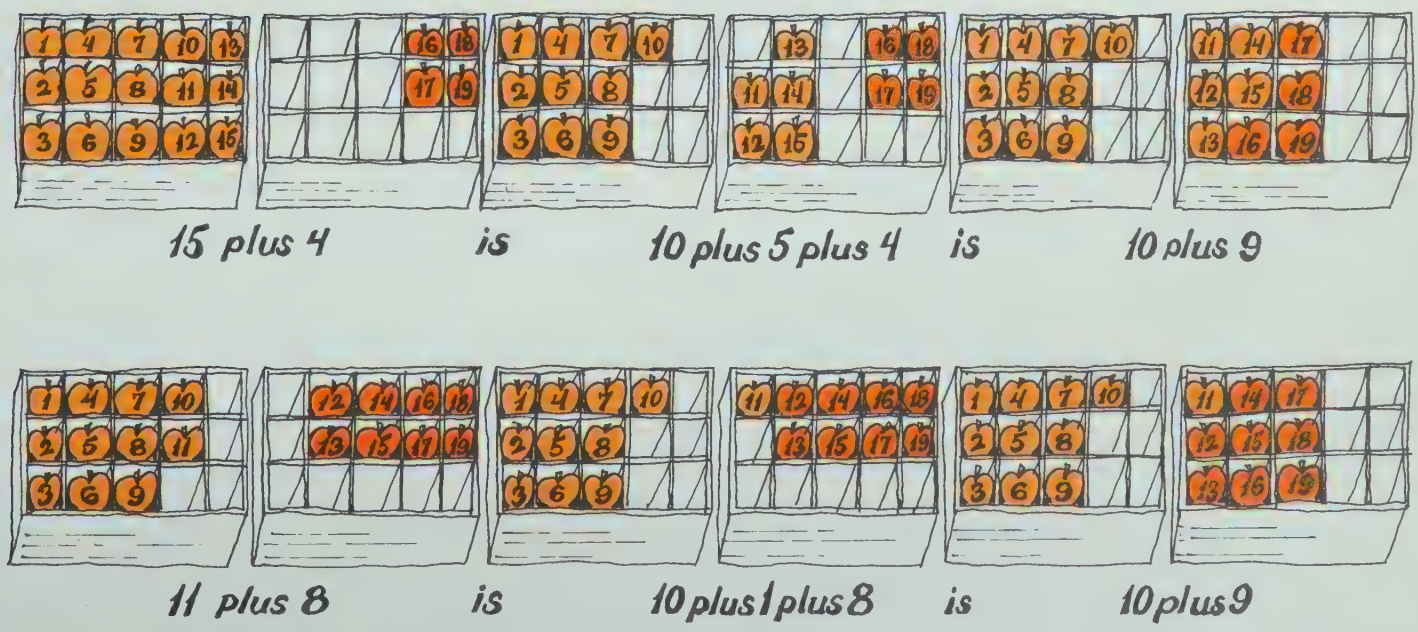

FIGURE 7

Activity 9

This activity uses the game *Nine-t-Nine Addition and Multiplication.* This game will strengthen the children's addition skills and introduce multiplication as repeated addition. The instructions are the same as those for *Nine-t-Nine Addition.* Children who have played the latter game should be able to play this game with little guidance from you. Although the directions are written for the children to read, do not hesitate to read the directions to them if you feel it is necessary.

In this activity, multiplication is introduced as repeated addition. If your children have not had previous experience with multiplication, you should point out another way of writing $3 + 3 + 3 + 3 = 12$. This sentence states that four *3's* are *12,* or $4\ (3\text{'s}) = 12$. In mathematics, we write $4 \times 3 = 12$ which is read "*4* sets of *3* are *12.*" For another example, if we write $5 \times 7 = 35$, we say "*5* sets of *7* are *35*", which can also be written $7 + 7 + 7 + 7 + 7 = 35$.

You may wish to provide the children with additional multiplication number sentences like those on the *Nine-t-Nine Addition and Multiplication* board.

Directions for the Teacher

Put out the board, the four cars, the two bridges, the ten-tokens, the spinner, and one set of latent-image answer sheets, and a magic pen for each player.

Call the attention of the players to the △, □, and the Toll Booths. When the players receive instructions from the answer sheets, they will sometimes be sent to these points. Also call the players' attention to the counting line, which might help in their multiplying.

The game is ended when the players have three ten-tokens. The players may try *Bonus Road* if they like. You might want to give them a prize such as a paper ribbon if they complete this road.

Directions for the Players

The players follow the same directions as they did for *Nine-t-Nine Addition.*

Materials

Nine-t-Nine Addition and Multiplication, 1 game consisting of one board, four toy cars, two bridges, twelve ten-tokens, one spinner, and one instruction sheet (*Module 30*)
(Note: Divide the face of the spinner in half and mark it as shown in Figure 1.)
Nine-t-Nine Addition and Multiplication Answer Sheets, 4 spirit masters (*Module 30*)
Magic pens, 4, image developers (*Module 30*)

Generalizing Experience

This activity assists the children in generalizing what they know about addition by grouping in tens to the addition of one- or two-digit numbers having a sum less than *100.* To do this, each number is separated into sets of tens and units, which are then added separately. Thus, $53 + 15$ is the sum of (5 tens and 3) and (1 ten and 5), or (6 tens and 8), or *68.*

Help the children think about the procedures for adding two two-digit numbers by illustrating the following steps, shown here for the addition of *21* and *63.*

$21 + 63 =$ (2 tens and 1) and (6 tens and 3)
$=$ (2 tens and 6 tens) and (1 and 3)
$=$ 8 tens and 4
$= 84$

You may need to assist the children in thinking about the way to add a one-digit and a two-digit number, for example, the addition of $9 + 15$.

$9 + 15 = 9 + 1$ ten $+ 5$
$=$ 1 ten $+ 14$
$=$ 2 tens $+ 4$
$= 24$

Continue with such examples as the two above. Let the children work on their own as much as possible.

Materials

Writing paper, several sheets for each child
Pencils, 1 for each child

APPRAISAL

Select at least two of the following activities.

1. Ask the children to use the numeral *10* in various contexts; for example, the tenth day of each month, the tenth page in a book, ten marbles in a bag, ten soda straws in a box.

Ask a child to express the numeral *14* in a variety of ways. The child should use language such as, 1 ten and 4 more. Ask other children to respond in the same way to other numerals, including *20, 37,* and so on.

Ask a child to describe numbers using the language "one less than" and "one more than." Repeat the question often and in varying circumstances.

2. Show a group of four or five children two sets of objects that have a combined total of about twenty members. Ask each child to write a numeral that represents the total number of members. Repeat this for another pair of sets having a combined total of about twenty members.

3. Play the question-and-answer game described at the end of *Activity 2,* but include some numbers that are greater than *9.* Have a twenty-member set of objects available for the children to use for demonstration.

4. Give the children pairs of numbers between *0* and *99,* and have them supply their sum, provided the sum is less than *100,* and provided they are familiar with the grouping-by-tens procedure of *Activity 8* and the *Generalizing Experience.* Give them several number sentences to complete, such as *16 + 21 = ?.*

5. Write a number sentence, such as *13 + ? = 17,* on the board and have the children complete the sentence. Use number sentences in which the total is twenty or less.

Materials

Objects, 20, such as cubes, paper clips, stones, marbles, and bean seeds

COMPETENCY MEASURE

Give the child 13 different objects arranged as a set of eight and a set of five.

TASK 1 (Objective 1): Say, Join these sets and state how many members are in the set. The child should join the sets and then state that there are thirteen members in the new set.

TASK 2 (Objective 2): Say, Write a number sentence, using numerals and symbols, to show the sum that you have shown with the objects. The child should write *8 + 5 = 13, 5 + 8 = 13, 13 = 8 + 5,* or *13 = 5 + 8.*

TASK 3 (Objective 2): Write *2 + 7 = 9* on a piece of paper and show it to the child. Say, Read this sentence to me. The child should say, "Two and seven are nine," "The sum of two and seven is nine," "Two and seven is another name for nine," or "Two and seven equals nine."

TASK 4 (Objective 3): Write *1 + 6 = ?* on a piece of paper and say, Supply the missing numeral in this sentence. The child should write the numeral *7.*

TASK 5 (Objective 3): Write *5 + ? = 7* on a piece of paper and say, Use a numeral to complete this sentence. The child should complete the sentence to read *5 + 2 = 7.*

TASK 6 (Objective 4): Write the numeral *35* on a piece of paper and show it to the child. Say, Describe this number in terms of sets of 10. The child should say something like, "Thirty-five is the same as three tens and five."

TASK 7 (Objective 5): Say to the child, What number comes before 35 and what number follows it? The child should respond with the numbers *34* and *36,* respectively.

TASK 8 (Objective 6): Say to the child, Name the sum of the numbers 31 and 45. The child should state "76," using any method he or she likes for finding the sum.

TASK 9 (Objective 7): Say to the child, If four boys each have 5 pennies, how many pennies do they have together? The child should say, "20." Do not insist that the child use any particular method.

Materials

Objects, 13, a variety
Writing paper, 1 sheet for each child
Pencils, 1 for each child

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SCIENCE... A PROCESS APPROACH II

MODULE
31

Communicating/d

Life Cycles

OBJECTIVES

At the end of this module the child should be able to

1. *DESCRIBE* an animal according to several of its characteristics.
2. *DESCRIBE* the characteristics of a young animal as it grows and changes from one stage to another.

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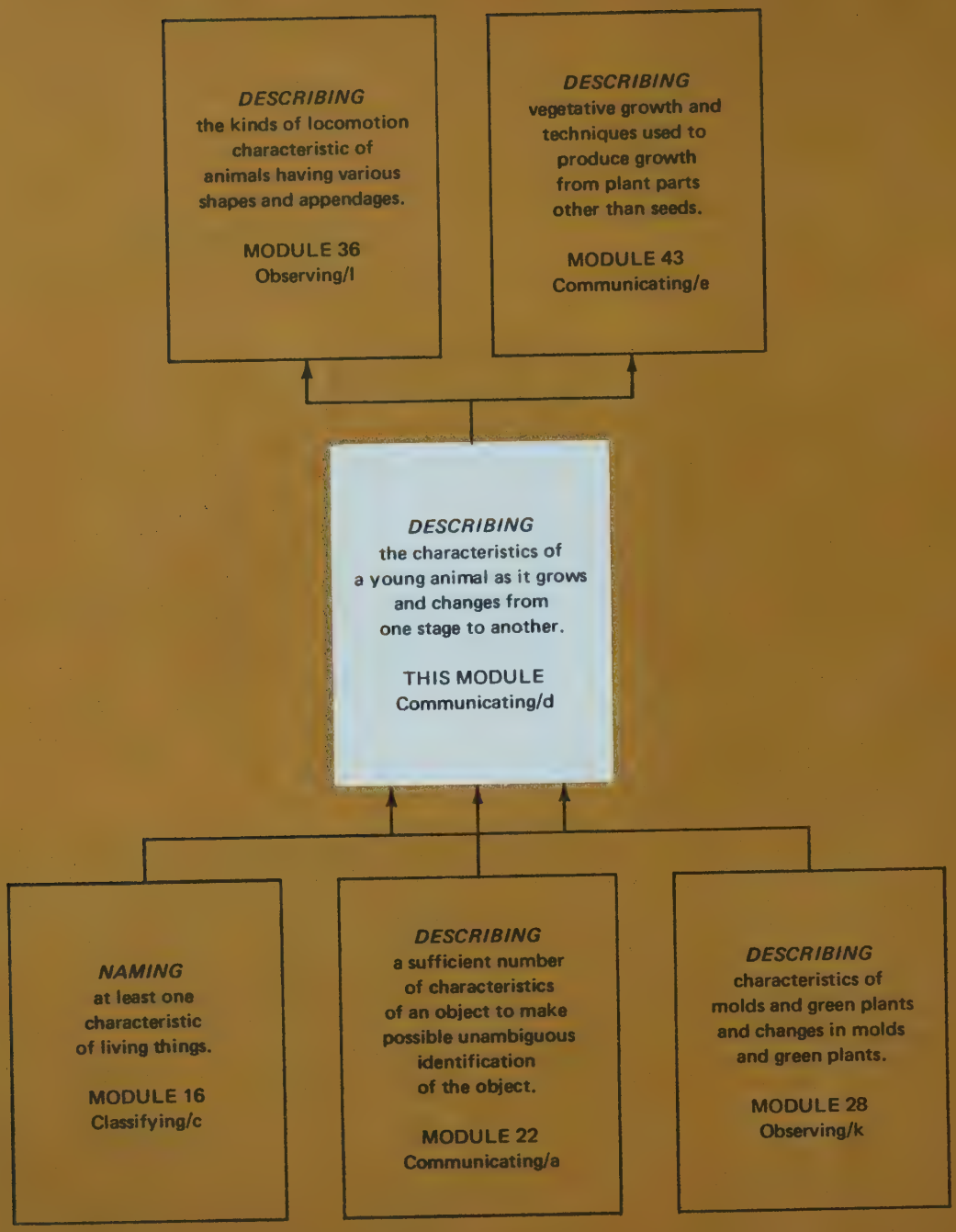
SEQUENCE


DESCRIBING
the kinds of locomotion characteristic of animals having various shapes and appendages.
MODULE 36
Observing/l
DESCRIBING
vegetative growth and techniques used to produce growth from plant parts other than seeds.
MODULE 43
Communicating/e
DESCRIBING
the characteristics of a young animal as it grows and changes from one stage to another.
THIS MODULE
Communicating/d
NAMING
at least one characteristic of living things.
MODULE 16
Classifying/c
DESCRIBING
a sufficient number of characteristics of an object to make possible unambiguous identification of the object.
MODULE 22
Communicating/a
DESCRIBING
characteristics of molds and green plants and changes in molds and green plants.
MODULE 28
Observing/k

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

The emphasis of this module is on communicating in clear, concise language the observed characteristics of animals and changes in these animals as they develop. It is important, therefore, that the children be given opportunities to observe many different living organisms, to make these observations over a period of time, and to communicate orally and in writing.

During all of the activities, encourage the children to observe carefully and to make their descriptions as detailed and complete as possible. In the *Introduction*, children discuss the categories that will be useful in describing animals. The children may suggest such categories as shape, size, color, and texture; these have been discussed in previous modules. Some children may suggest these two additional categories: means of locomotion, such as legs or wings, and pattern of motion, such as the wiggling of a snake or the hopping of a frog.

It is preferable for the children to undertake this module during the fall or spring season because *Activities 1, 2,* and *3* require the collection of materials from the outdoors.

This module offers you a choice of activities. The selection should be based on the resources and materials available. Select *Activity 1* or *2*; one includes a field trip and the other does not. Choose one or more of the remaining three activities depending on the availability of monarch butterflies, brine shrimp, and mealworms, respectively. If you select *Activity 4*, it will be well to also use *Activity 3* or *5* so that the children will have some experience with the life cycle of insects.

Vocabulary

The children will come in contact with only some of the following words, depending on the animals selected for study.

egg	adult
egg case	chrysalis (optional)
organism	larva
locomotion	brine shrimp
cocoon	life cycle (optional)
pupa	

Advance Preparation

For *Activity 3*, caterpillars of the monarch butterfly are needed. You will find these caterpillars on milkweed plants (see Figure 1). Milkweed grows in vacant lots, along roadsides, in marshes, in ditches, and in fields; when you break a milkweed stem, it emits a white milky fluid. Monarch butterflies migrate, spending winter in the south and summer in the north. Check with your state department of agriculture to find out when the caterpillars may be found in your area.

Activity 4 requires brine shrimp and a salt solution. The brine shrimp can be purchased at most tropical fish stores. The salt solution can be prepared by a group of children and allowed to stand for 24 hours. See *Materials* for directions.

You can obtain mealworms for *Activity 5* at a pet store, where they are sold as food for birds and reptiles. The mealworm cultures should be started before you begin the activity; you might set them up when you begin this module. Specific instructions are found in *Activity 5*.

FIGURE 1

INSTRUCTIONAL PROCEDURE

Introduction

Show the children an adult animal and its young—for example, a cat and kittens, a gerbil and cubs, a frog and tadpoles, or adult tropical fish and fry. The more examples present in your classroom, the better. While you may use pictures of these organisms as substitutes, living animals are far more desirable.

Have the children describe several of the characteristics of the adult and then of the young. The group should then briefly compare the two sets of observations and try to list several categories that would be useful in making similar comparisons for any animal. Your children may suggest such categories as shape, size, texture, color, symmetry, means of locomotion, and pattern of motion.

Prepare the children for observing organisms on a field trip (*Activity 1*) or in the room (*Activity 2*). Have the children discuss the different categories of observations, and ask the children how they will use each of these categories to describe the organisms they observe.

Materials

Adult animal and its young, at least one live example, or pictures of adult and young

Activity 1

Take the children on a field trip in the schoolyard, a nearby park, or a weed-filled lot to collect animals and vestiges of animals at different stages of their life cycles.

Divide the group into teams of four, and divide each team into two pairs. Each child will then have a partner throughout the activity, as well as a team to which he and his partner belong.

Before beginning the hunt, ask the children why it is important to replace any log or rock or other object that they turn over. Also ask why they should return those organisms that they do not keep to the place where they were found.

Ask the pairs of children to search for small animals or signs of small animals. When two partners find something of interest, they should show it to the other pair in their team, and carefully describe where they found it; for example, they might say that they found insect egg cases in the damp soil under a log. The other pair should then find a similar place—still within the defined area—where they might find evidence of the same organism or a similar one. While doing this, the second pair of children will almost certainly find items of interest that they can share with the other two partners.

Bring the children together after they have had an opportunity to find several items. Ask if there is any relationship among the items. Questions such as the following may be helpful.

Do young animals always look like older animals of the same kind?

What have you found that will show this?

Can you show us something that tells us that animals change?

What have you found?

Select those items that can be taken back to the classroom. You may be able to keep only parts of animals, such as egg cases and eggshells, feathers and molted skin. Keep living animals too, if this is permissible, and if you can maintain them well in your room.

When you return to the room, put the collected items on a table or in some other place where all the children can see them easily. Ask one child to carefully describe (without pointing) an object that he contributed, so that another child can select it from the collection. Be sure that the children describe the characteristics of each item, such as its shape, size, texture, color, and movement. Have the children compare the characteristics of the items.

Emphasize the precise use of terminology when describing shapes and other characteristics by asking such questions as these: How do you know it is rough? How do you know the earthworm is shaped like a cylinder? Such questioning will require the child to demonstrate a test for identifying texture or for identifying shape. In this way, you may more clearly assess the children's use of the descriptive terms.

Materials

Bags, paper and plastic, to hold items collected on field trip
Several old spoons, trowels, or other digging tools
Hand lenses, 15 (*Module 31*)
Live animals and parts of animals, collected during field trip

Activity 2

If you cannot take the children on a field trip (*Activity 1*), go to a nearby field or forest, and collect animals and vestiges of animals at various stages of their life cycles for the children to examine. Try to include in the collection representative stages of life cycles, such as insect egg cases, cocoons, and caterpillars. Encourage the children to bring in other items to supplement this collection.

Arrange the samples on the table so that the children can see them easily.

Ask one child to look over the collection and choose an item to describe. Inform the child that he must not point out the item in any way except by a verbal description. Have the child compare the characteristics of the item with those of the other items in shape, size, texture, color, and movement. Emphasize the need for precise terminology in descriptions by asking such questions as these: How do you know it is rough? How do you know that the earthworm is cylindrical? Such questioning will require the children to demonstrate a test for texture or for shape. In this way, you can more clearly assess the children's use of the descriptive terms.

After the child has completed the description, invite another child to select the item from the collection on the basis of the first child's description. Be sure to stress that the most complete descriptions are those that will help the second child to identify the item.

Materials

Animals and parts of animals, collection including representatives of various stages of development, such as egg cases, cocoons, and adult insects.
Hand lenses, 15 (*Module 31*)

Activity 3

During *Activity 3*, the children observe monarch butterfly caterpillars (larval stage) form chrysalises (pupal stage), and finally emerge from the chrysalises as adult butterflies; the egg stage is the only developmental stage that the children do not observe. It takes about 3 to 4 weeks for the monarch caterpillar to develop into an adult butterfly.

Point out to the children that when they observed organisms during the field trip or in the room, they described these organisms at just one point in time. Inform them that during the next few days they are going to observe *changes* in living things. The descriptions that they make next should therefore stress the changes that have occurred in the animal.

Without any comment, bring into the room a cage (see *Materials*) that contains one or more monarch butterfly caterpillars. Show the children one caterpillar and ask them to describe it carefully. Someone may say, "It is a caterpillar" or "It is a monarch caterpillar." Ask that child if what he said accurately described what he observed. If he says it does, ask him if someone who had never seen a caterpillar would know what one looked like from his description. The children should recognize that the statement "It is a caterpillar" is not an adequate description. Together record a complete description of the caterpillar as a list of the key words used, as a story in a class news bulletin, or as a report on audio tape.

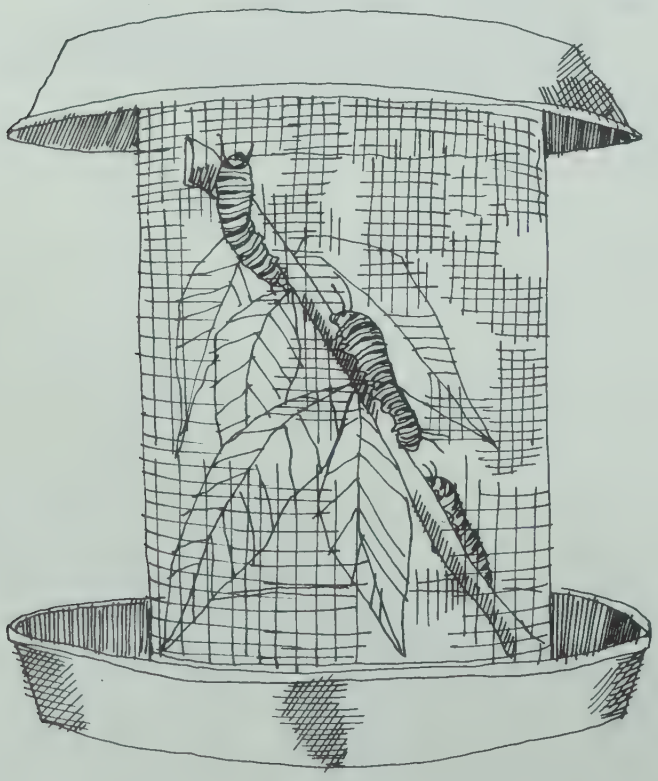

FIGURE 2

Ask the children if they would expect to see any changes in the caterpillar the next day. Tell the children that they will make daily descriptions for the next 3 to 4 weeks as the caterpillar changes to a pupa and finally into an adult butterfly. Explain that monarch butterfly caterpillars need milkweed leaves to eat and that the caterpillars should always have a supply of leaves. As the days pass, have children check the butterfly cages frequently, and add milkweed leaves whenever necessary. Have the children help you release the adult butterfly outdoors at the completion of this activity.

Materials

Monarch butterfly caterpillars, several
Milkweed leaves, and twigs, for feeding monarch caterpillars, several
Cage, 1, for caterpillars
(Note: You can make the cage by rolling a piece of wire window screen (*Module 31*), about 25 x 50 cm, into a cylinder and stapling it to hold that shape. Set one end of the cylinder into a pie pan (*Module 31*). Put milkweed leaves, some twigs, and the monarch butterfly caterpillars inside it. Cover the top of the cylinder with another pie pan (*Module 31*). See Figure 2.)
Hand lenses, 15 (*Module 31*)

Activity 4

Brine shrimp are tiny, salt-water organisms that children can easily raise. The changes that these organisms undergo during their development are interesting to observe, and provide a contrast to the development of insects that the children may observe elsewhere in this module. It will take several weeks for the brine shrimp to develop from eggs to adults.

Begin this activity by giving each pair of children a plastic container. Have the children label their containers by first attaching a piece of tape to the container and then writing their names on the tape with a pencil or a felt-tipped pen.

Pour some salt solution into each container. Use a flat toothpick to transfer 20 to 30 brine shrimp eggs to the surface of the salt solution in each container. Do not tell the children that the objects are brine shrimp eggs.

Distribute magnifying lenses and ask for descriptions of the objects. The children should mention size, shape, and color. Keep a record of these descriptions, in the form of a list of key words used, a story in a class news bulletin, or as a report on audio tape. Tell the children that together you will make this kind of record every day. Ask them why this should be done. The children should realize that it is best to record their observations in order to remember them. Since the children are going to watch for all the changes they can observe, their descriptions should take particular account of the changes.

Ask the children to place their containers on a shelf where the temperature is maintained at 23° to 28°C and where there are no drafts or direct sunlight. The children should observe the contents of these containers during the next 4 days. Do not tell them what to look for, but encourage them to observe any changes that occur. The eggs should hatch in 1 to 3 days, and the children will see the small larvae swimming. At this time add a pinch of yeast to the containers for food.

As the eggs hatch, ask some children to describe what they observe so that other children will know what to look for in their containers. After the children have made their observations and descriptions, identify the organisms as brine shrimp and ask questions such as the following:

How big are the young shrimp?

What is their direction of motion?

Is the motion smooth or jerky?

Where did the young shrimp come from? (The children will probably suggest that they hatched from the eggs floating on the surface.)

Did you actually observe this hatching, or are you only guessing?

Do any of the eggs appear to have changed or to be empty, like the shell of a chicken egg after the chick hatches out?

Conduct much of this discussion informally with individuals or with small groups of children as they observe the contents of their containers. The children should continue to record their descriptions and perhaps make drawings of what they observe.

The children can maintain their cultures for several weeks by feeding the shrimp small pinches of yeast every few days and by adding water to replace water that evaporates. The brine shrimp will gradually grow to be about 1 centimeter in length. (See Figure 3.) It is possible that after a few weeks some of the female shrimp will produce eggs that can be seen attached to the body in an egg sac.

Materials

Containers, 15, 250-ml, clear plastic, with covers (*Module 31*)
Brine shrimp eggs, 1 container (*Module 31*)
Toothpicks, several, flat
Hand lenses, 15 (*Module 31*)
Yeast, 1 package (*Module 31*)
Salt solution, 4 liters

(Note: The solution should be prepared by a group of children, under your supervision, and allowed to stand 24 hours. Have the children dissolve 140 grams of noniodized salt (*Module 41*), or rocksalt, in 4 liters of water. Use only bottled water, spring water, or tap water that has stood for 24 hours and that does not contain a softening agent.)

Thermometers, 2, Celsius (*Module 41*)
Drawing paper, 1 sheet for each child
Pencils, 1 for each child

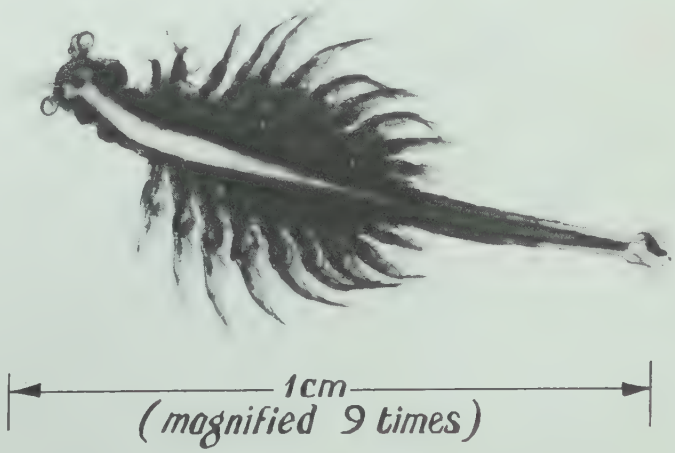

FIGURE 3

Activity 5

During this activity, the children observe the four distinct developmental stages of the mealworm: egg, larva, pupa, and adult. Mealworms are the larval stage of a black beetle that lays its eggs in cereal products. They can easily be kept in the classroom, and children can hold both the adults and the larvae in their hands and observe them.

The life cycle of the mealworm normally takes one year, but it may be hastened if the insect is raised in a warm environment. A culture should be maintained year round so that all stages are available for observation. If you do not already have such a culture, start one immediately, and then have the children care for and observe these organisms throughout the year.

Mealworms are clean and easy to maintain. Place enough bran or oatmeal in a 2-liter container to cover the bottom to a depth of about 5 to 6 centimeters. Next put some mealworms in the container. Place pieces of paper towel on the surface of the bran (mealworms will usually be found "burrowing" through this toweling) and occasionally add a slice of carrot or apple for moisture. You may want to place a small number of mealworms in small individual containers, such as baby food jars. The children should count the mealworms and keep track of the number from time to time.

Encourage the children to communicate their observations of the characteristics of each stage and to compare larvae, pupae, adults, and eggs if these are observed.

Materials

Mealworms, 100
Container, 1, 2-liter, clear plastic (*Module 31*)
Bran or oatmeal, 1 box
Paper towels, several
Carrot or apple, 1 large slice
Hand lenses, 15 (*Module 31*)

Generalizing Experiences

1. Play a game in which each child in turn is asked to think of some object, living or nonliving. Have one child begin by describing his object in such a way that another child can tell what it is from the description. The child who is successful at guessing the object can then have a turn at giving a description. Pairs of children might play the game by writing their descriptions, exchanging descriptions, and trying to guess what object the other is thinking of.

2. The children may wish to make "life cycle wheels" (see Figure 4) as a way of describing the developmental stages of insects. Help each child select for this purpose an insect having a life cycle of three or four stages. Discuss the meaning of "life cycle" briefly.

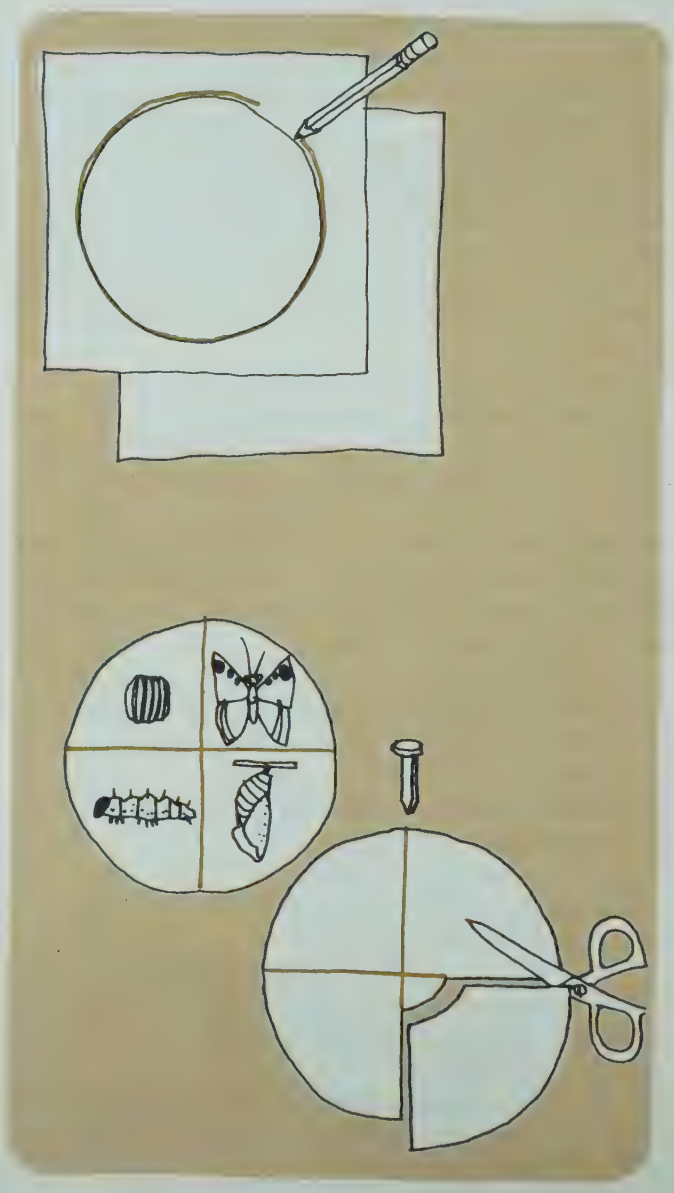

FIGURE 4

You will probably have to help the children find the needed life-cycle pictures. Children's encyclopedias and nature magazines have many fine pictures of insects in all stages of their life cycles. The children can make their drawings from these.

Give each child two sheets of heavy paper or light cardboard. Also provide circular patterns. Give the children the following directions.

1. Use the pattern to trace a circle onto each sheet of paper, and cut out the circles.
2. Divide each circle into equal-sized wedges, one for each stage of the insect's life cycle.
3. Draw one stage of the insect's life cycle on each wedge of one circle.
4. Cut one wedge from the second circle, but take care not to cut all the way to the center (see Figure 4).
5. Cover the circle of illustrations with the second circle.
6. Use a paper fastener to fasten the circles together at their centers.

After the life cycle wheels have been completed, pair the children and have them exchange wheels. Tell them to take turns describing stages of the life cycle for the other child to locate. A description should include several characteristics of one stage of the life cycle so that the partner can locate that stage on the wheel. Then the description might be extended to include changes that take place from one stage to another so that the partner must identify both stages involved. Tell the children to take turns after each description, whether or not the identification is correct. (See Figure 5.)

Materials

Heavy paper or light cardboard, 60 sheets
Circular patterns, 6, cardboard (*Module 31*)
Paper fasteners, 1 package (*Module 31*)
Pencils, 1 for each child
Scissors, 1 for each child
Crayons, 1 box for each child

FIGURE 5

Silkworm Life Cycle

FIGURE 6

APPRAISAL

Put two or more sets of objects in a box. Please note that the objects listed in *Materials* are only suggestions. Other objects can be substituted. At least one set of objects should show the same organism, or part of an organism, in different stages of its life cycle. Do not allow the children to see the contents of the box. One by one, take objects from the box and show them to the children. Pass every object to each child so that he may touch, lift, smell, and look at it. Select the objects so that you do not show related ones in sequence and do not always show the youngest of a set first. For example, do not show a green banana first, a ripe banana second, and an overripe one third. The children should, on their own, suggest the order of the bananas and state the criteria used to order the fruits.

As they observe each object, call upon different children to describe it orally. Then call for a vote from those who believe that the object is living and from those who believe that it is not living. Ask the children to state the basis for their classification. After the children have observed, described, classified several objects, some of them related, ask them to compare the objects. You might ask questions such as the following: Are any of the objects similar? Which characteristics still appear to be slightly different? Answers to the last question should include some mention of changes during life cycles, seasonal changes, and changes due to aging.

Materials

Box, 1

Objects, two or more of the following: closed and open pine cones of the same species; fresh and dried fruit of the same variety; one green, one ripe, and one overripe fruit of the same species; eggs, larvae, pupae, and adult of same insect; fern leaves at various stages of uncoiling; dried starfish, sand dollar, and sea urchin

(Note: At least one set of items should show the same organism at different stages of development.)

COMPETENCY MEASURE

TASK 1 (Objective 1): Show the child a mature water snail (or some other small animal that the children have not studied) in a suitable container. Say, Describe the object you see in the container. Tell me as many things as you can about it. The child should give a description that includes at least three characteristics, such as size, shape, color, and texture.

TASK 2 (Objective 2): Show the child the picture card of the silkworm eggs, cocoon, and adult moth. (See Figure 6.) Say, Tell me as many things as you can about changes that took place in this insect. The child's description should include changes in such characteristics as size, texture, color, shape, means of locomotion, and pattern of locomotion.

Materials

Mature water snail or other small animal, 1

Container, 1, 250-ml, for snail or other small animal (*Module 31*)

Picture card, 1; illustrating silkworm egg, cocoon, and adult moth (*Module 31*)

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31 Communicating/d

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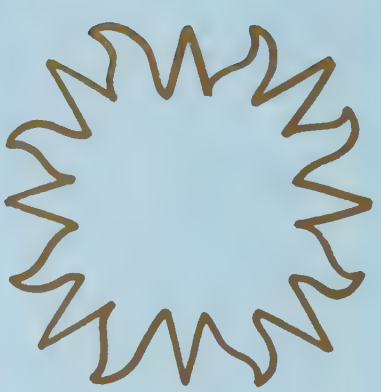

A PROCESS APPROACH II

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SCIENCE... A PROCESS APPROACH II

MODULE

32

Classifying/d

A Terrarium

OBJECTIVES

At the end of this module the child should be able to

1. *DEMONSTRATE* the separation of living organisms into categories and sub-categories.
2. *CONSTRUCT* a simple classification scheme and *DEMONSTRATE* its use.
3. *DEMONSTRATE* the placing of new organisms in the appropriate categories and sub-categories of a classification scheme.

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SEQUENCE

DESCRIBING the distinguishing characteristics of a solid, a liquid, or a gas.
MODULE 39 Measuring/g
DEMONSTRATING a specified method for classifying components of a given mixture according to the size of the particles.
MODULE 42 Classifying/e
CONSTRUCTING and *DEMONSTRATING* the use of a punch-card system to classify objects by using subsets.
MODULE 56 Classifying/f
CONSTRUCTING and *DEMONSTRATING* the use of a simple classification scheme for living organisms.
THIS MODULE Classifying/d
CONSTRUCTING groupings of living and non living things on the basis of observable characteristics.
MODULE 16 Classifying/c

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

This module provides opportunities for children to study, in some detail, plants and animals they have collected. The children construct a simple classification scheme and use it to classify various groups of organisms. In an earlier experience *Living and Nonliving Things* and *Trees in Our Environment, Classifying c, Module 16,* the children classified living and nonliving things.

In addition to developing a classification scheme for a number of organisms, the children place organisms into an already existing scheme. For this purpose, they must be able to recognize some of the general characteristics of a specific animal or plant. General characteristics may be the presence or absence of legs, antennae, leaves, or flowers, or that the organism is land-dwelling or water-dwelling.

A dichotomous classification scheme is used in this module. The children begin by dividing things into two groups: living and nonliving. Then each of these groups is divided again. At each new division, the things in a group are divided into two new groups. For example, the group composed of all animals with legs can be divided into two groups: animals with antennae and animals without antennae. To help the children see what they are doing as the scheme is developed, list the names of the plants and animals included in each grouping. Perhaps these lists will illustrate the idea that at each subdivision in a classification scheme there is a reduction in the number of kinds of organisms in each group.

For most geographic areas, it is recommended that this module be started early in the fall when the children will be able to collect plants and animals.

Vocabulary

terrarium (plural terraria)
characteristic
classification scheme
category
sub-category

INSTRUCTIONAL PROCEDURE

Introduction

Divide the children into three or four groups and mark off a corresponding number of sections on the chalkboard. Label the sections and name the groups to correspond. Use letters *A, B, C, D* or name the groups as you prefer.

Ask the groups to name living things, plant or animal, other than people, that they have seen in or around their houses or school. As each group names an organism write the name in that group's section of the chalkboard. If a group names an organism that was already named by another group, ask the group to think of another organism to put in their list.

After each group has named five or six organisms, suggest that the children work in their groups to develop more complete lists. Help the children with the spelling and naming of organisms. Let the children refer to books in the room or in the learning resources center.

After the groups have compiled their lists, add the names of the new organisms to the lists on the chalkboard or have the groups post their lists on the bulletin board where all the children can examine them.

Materials

Writing paper, 1 sheet for each child
Pencils, 1 for each child

Activity 1

Ask the children to bring in some of the organisms they have named in their lists and others that they may find that are not on the lists. Show them a large container and a 2-liter container and tell them that they are going to make terraria for the organisms they bring to school. Remind the children that they can bring in both plants and animals, but that the organisms should be small enough to live in the containers.

Divide the children into groups and give each child a plastic bag to hold one or more organisms he may find to bring to school. Remind the children that they must ask permission to collect organisms from people's yards. Also remind them that if they collect organisms from wooded areas or vacant lots they should leave things as much as possible as they found them. If they turn over a stone or a stick and find ants or worms or pill bugs, they should replace the stone or stick after they have collected their organism.

When the children bring their plastic bags of organisms to school, give each group a 2-liter container for the small organisms. Have them put the larger plants and animals in the large container. Suggest that they might

bring in some soil, humus, twigs, leaves, and so on, to make an environment like that in which they found the organisms.

Discuss with the children the various things they will need to do to take care of the plants and animals they bring in for the terraria. The children should put a shallow container of water in each terrarium. Give them some suggestions for the kinds of food to bring in for the animals. They should be reminded not to overwater the plants. They will need to decide whether a terrarium should be covered with plastic wrap, screen, or in some other way.

Assist the children if necessary in putting the organisms, soil, and so on, into their terraria.

Materials

Container, 1, 20-40 liter, clear plastic or glass, for use as terrarium
Containers, 6, 2-liter, clear plastic, for use as terraria (*Module 32*)
Organisms, assortment found locally
Plastic bags, 30 (*Module 32*)
Petri dishes, 3, plastic, to be used as water containers in the terraria (*Module 32*)
Plastic wrap, or wire or plastic screen, several pieces, to cover terraria

Activity 2

Prepare chalkboard charts or wall charts on which to record the names and characteristics of the plants, animals, and nonliving material the children have in their terraria. Let the children help decide what characteristics to put on the charts. Some possible characteristics for animals are suggested in Figure 1. Let the children decide what characteristics they want to use. They might write "yes" or "no" to indicate the presence or absence of each characteristic.

Have the children make similar charts for the characteristics of plants and nonliving material they have in their terraria.

Materials

Marking pen, 1
Pictures of plants and animals, for wall chart (optional)
Shelf paper or tagboard, for wall chart of plant and animal characteristics
Terraria, from *Activity 1*

Activity 3

Have each child make a chart similar to the one shown in Figure 2; or designate a child in each group to make the chart. Have the groups observe their terraria and record on the chart *all* the objects they find inside. Both living and nonliving objects should be listed. Have the children cite several characteristics for each object. Demonstrate this procedure to the children by writing on the chalkboard the name of an object common to all terraria. Then, ask the children to observe the object and tell some things about it. List the characteristics they suggest next to the name of the object. Explain that they are to list several

CHARACTERISTICS OF ANIMALS

Name or Picture	What It Looks Like							How Big Is It		How It Moves			
	Tail	Fur	Ears	Eyes	Legs	Feathers	Wings	Less than 5cm long	More than 5cm long	Flies	Crawls	Walks, Runs	Jumps
[illegible]	no	no	no	yes	yes	no	yes		X				X

FIGURE 1

characteristics for each object in the group's terrarium. Now moving from group to group, help the children to note and record characteristics, such as color, shape, odor, size in metric units, sounds, textures, movements, number of legs and so forth, for each object recorded.

After the children have had time to list the objects and their characteristics, ask several groups to report the names and characteristics of one plant, one animal, and one other object in their terrarium. As each object is named, print the name on a card, tape the card to the chalkboard, and record the characteristics on the board as shown in Figure 3. The objects in Figure 3 are only examples.

Ask the children to think of a way to classify the objects listed on the board into two groups. If no one has an idea, rearrange the cards into two groupings as shown in Figure 4, and ask in what way all the things in Group A are alike. Then ask in what way all things in Group B are alike. Eventually the children should say that the *A's* are living and the *B's* are nonliving. Then print each of the categories, *all objects, living,* and *nonliving* on three cards. Using these three new cards, string, and masking tape or pins, arrange all the cards on a bulletin board as shown in Figure 5. Ask the children to tell you which objects should be classified under *living,* and which under *nonliving;* or have the children arrange the cards into the two categories.

Have each group make a chart similar to the chart you have made on the bulletin board, of all the objects in their terrarium. When the groups have finished their charts, refer to the chart on the bulletin board and ask whether the objects in these two categories can be divided into sub-categories. Someone may suggest that living things are either plants or animals, and nonliving things are either solid, like the soil and the container, or not solid, like water and bubbles. If these sub-categories are suggested, add them to the bulletin board chart and rearrange the cards as in Figure 6. Do not use these sub-categories if the children do not suggest them. Accept any logical sub-categories. The classification of nonliving objects need not be emphasized here, because it is presented in a later module in the classifying sequence. Ask the children to add the new categories to their group charts and to list the objects and organisms in their terraria under the sub-categories. Encourage the children to continue to classify the organisms as they bring them in for their terraria. If a group decides to develop their own classification scheme, encourage them, but insist that they be able to explain the scheme.

Materials

Writing paper, several sheets for each child
Pencils, 1 for each child
Index cards, 1 package, white (*Module 32*)
Marking pen, 1
String, 1 ball (*Module 35*)
Straight pins or masking tape
Terraria, from *Activity 1*

Object	Observations
dandelion	green, has leaves, yellow flower, does not move from place to place.
grasshopper	jumps, wings, green, large back legs.
container	plastic, holds water, 8 centimeters across.
turtle	has shell, four legs, breathes on land.

FIGURE 2

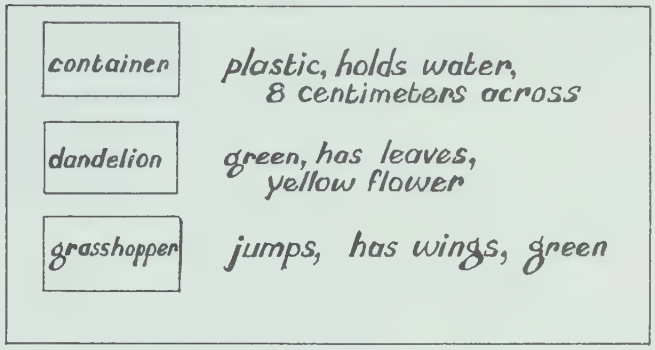

FIGURE 3

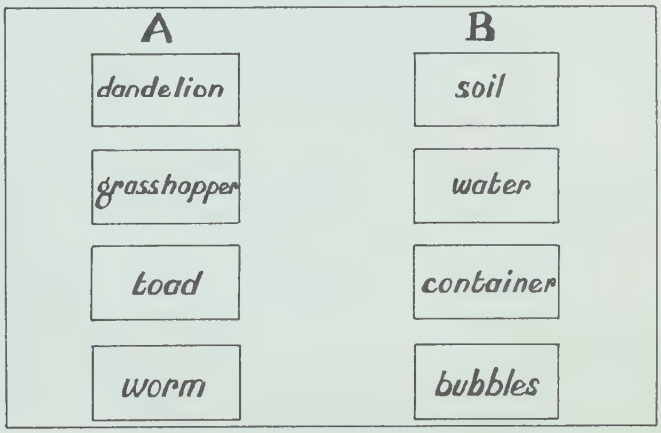

FIGURE 4

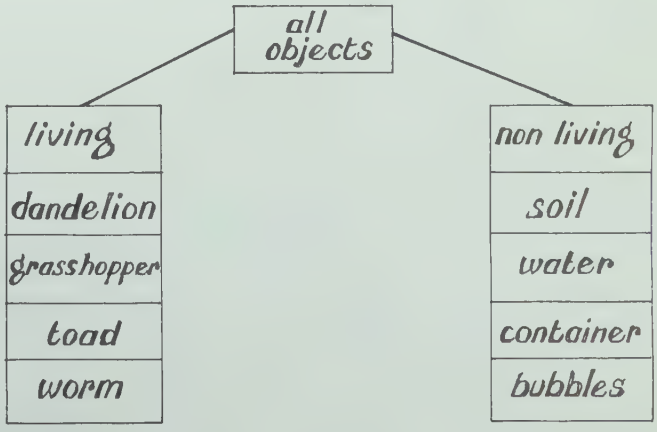

FIGURE 5

Activity 4

To help the children further develop their classification scheme, refer again to the chart on the bulletin board and ask if the animals could be divided into sub-categories. One sub-category might be legs/no legs. The children may suggest a different one. The animals in the legs/no legs group might be divided into two sub-categories—four legs/more than four legs. Again the children may suggest a different one. Add cards for the new categories to the classification scheme on the bulletin board and rearrange the cards as shown in Figure 6. Then add cards for the next sub-category and rearrange again as in Figure 7. Using the children's suggestions, have them develop sub-categories for classifying all the animals and plants found in the terraria.

Emphasize that the strings joining the cards, which indicate the categories, show that the organisms in a sub-category are included in each category above it. It is important that the classification schemes develop according to the children's suggestions. *No one* scheme is necessarily better than another. The sole criterion for judging the value of any classification scheme is its usefulness for some particular purpose. Until you know why particular characteristics are chosen as a basis for classifying, avoid giving the impression that those selected by the children are not good ones. For example, a classification scheme that distinguishes between "animals that bite" and "animals that do not bite" can be very useful, and is therefore perfectly valid.

Have the groups make wall charts of their classification schemes and keep them so that new objects or organisms can be added to them later. Encourage the children to bring in new organisms to add to the terraria. Have the groups classify the new organisms and show their classification on their wall charts.

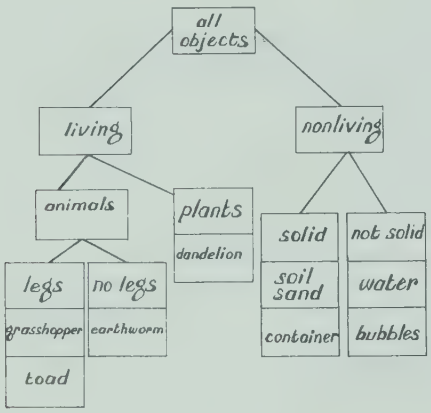

FIGURE 6

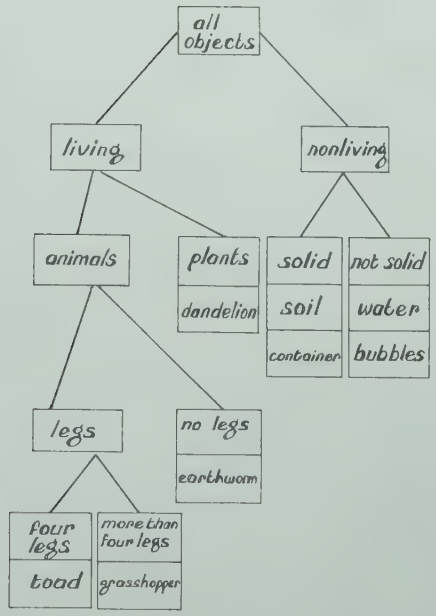

FIGURE 7

Materials

Index cards, 1 package, white (*Module 32*)
Marking pen, 1
String, 1 ball (*Module 35*)
Straight pins or masking tape
Shelf paper or tagboard, for wall charts

Generalizing Experience

Ask the children to find pictures of plants and animals in magazines or newspapers and bring them to school. If some children do not bring pictures they might draw and color some. After the children have decided on a classification scheme, help them make a wall chart. Have the children attach their pictures below the appropriate category cards.

As the children consider a new plant or animal, encourage them to decide whether or not the organism belongs to the existing categories, or whether it may have enough different characteristics to warrant the formation of a new category. If they can defend the need for a new category have them add a new card. Answer any questions the children have regarding characteristics not observable from the pictures.

Materials

Pictures of plants and animals, at least 30
Index cards, 1 package, white (*Module 32*)
String, 1 ball (*Module 35*)
Straight pins or masking tape
Shelf paper or tagboard, for wall chart
Marking pen, 1

APPRAISAL

Give each child a copy of *Describe the Organisms,* Figure 8. If any of the pictures on this sheet are of organisms not familiar to the children, substitute or delete those pictures. Read, one at a time, the following descriptions. As you read each description, tell the child to put the number of the description (1, 2, . . .) in the appropriate box on the sheet. For the given descriptions, the numbers should read (from top to bottom) 8, 3, 6, 4, 2, 7, 5, and 1.

1. Breathes on land, has four legs and no shell
2. Breathes on land, has more than four legs and a shell
3. Breathes in water, has fins and no shell
4. Breathes in water, does not swim, and has a shell
5. Breathes on land, is young, and does not look like the adult
6. Breathes on land, cannot move from place to place, has no leaves, and is not green.
7. Breathes in water, swims, is young, and does not look like the adult.
8. Breathes on land, has leaves, and cannot move from place to place

Materials

Describe the Organisms, 1 spirit master, Figure 8 (*Module 32*)
Pencils, 1 for each child

Describe the Organisms

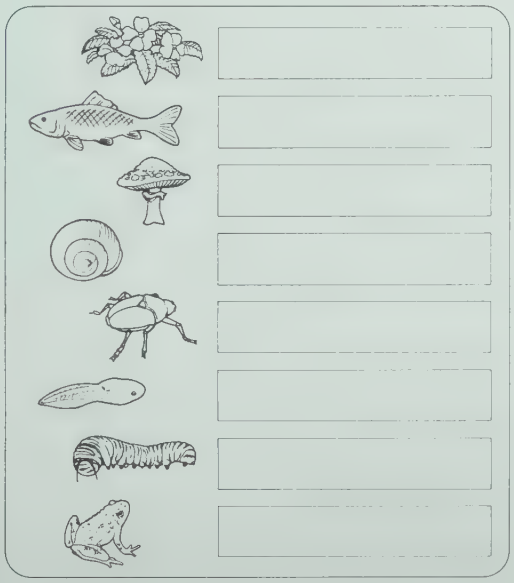

FIGURE 8

COMPETENCY MEASURE

Select six living organisms from the terraria in the room and place each organism in a small container on a table in front of the child.

TASK 1 (Objectives 1, 2): Say, Make a simple classification scheme with at least four categories and sub-categories for these organisms. The child should construct a classification scheme for these organisms.

TASK 2 (Objectives 1, 2): Say, Show where these organisms fit in your classification scheme. The child should classify at least four of the organisms correctly.

TASK 3 (Objective 3): Say, Select another organism from a terrarium and show where it fits in your classification scheme. The child should classify the organism correctly.

Materials

Living organisms, 7, from terraria
Containers, 7, 120-ml (*Module 41*)

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MODULE

33

Inferring/a

What's Inside?

OBJECTIVES

At the end of this module the child should be able to

1. *DISTINGUISH* between statements that are observations and those that are explanations of observations, and *IDENTIFY* the explanations as inferences.
2. *CONSTRUCT* inferences in terms of likelihood rather than certainty.

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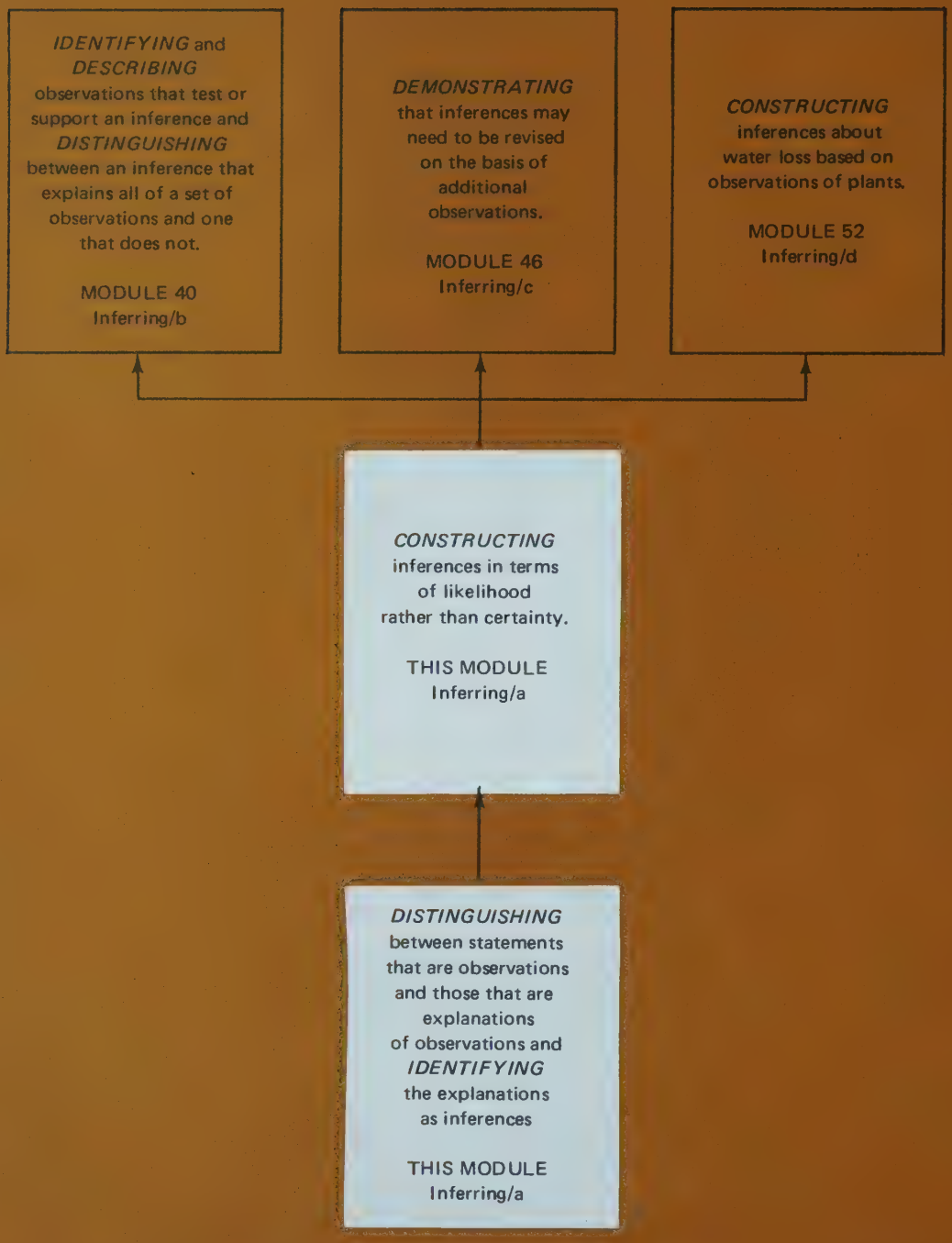
SEQUENCE


IDENTIFYING and *DESCRIBING* observations that test or support an inference and *DISTINGUISHING* between an inference that explains all of a set of observations and one that does not.
MODULE 40
Inferring/b
DEMONSTRATING that inferences may need to be revised on the basis of additional observations.
MODULE 46
Inferring/c
CONSTRUCTING inferences about water loss based on observations of plants.
MODULE 52
Inferring/d
CONSTRUCTING inferences in terms of likelihood rather than certainty.
THIS MODULE
Inferring/a
DISTINGUISHING between statements that are observations and those that are explanations of observations and *IDENTIFYING* the explanations as inferences
THIS MODULE
Inferring/a

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II** is described in the **Program Guide** available on request from
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RATIONALE

The purpose of this module, which introduces the process of *inferring* is to promote careful, conscious reasoning about observations. The children will practice distinguishing between what they can observe with their senses and what they can infer from their observations. They will learn that inferences are always somewhat tentative; consequently, they will learn to say that something "probably is . . . ," "might be . . . ," or "is likely to be . . . ," and so on.

Throughout the activities, make sure that the distinction between observations and inferences is clear. Observations are generated first; then inferences follow. Inferences may be defined as statements that are explanations of observations.

Wrapped packages are used to introduce the subject. The children trying to discover the contents of a package must gather clues by observing the package without opening it. The amount of information available to the children, then, is limited only by their own ingenuity in making observations. Although they cannot see what is in the wrapped package, they may infer quite a bit about its contents by examining it.

Encourage the children to make observations with all of their senses, such as—sight, touch, smell, and hearing. *CAUTION: The Sense Of Taste Should Not Be Used On Unknown Materials.* Because certain substances might make the children ill, remind them never to taste unknown materials.

When the children make inferences, remind them that these *are* inferences. Children will often state as a certainty what is actually an inference. For example, a child may say, "I'm sure that the box is empty." Make it clear that a limited number of observations usually has several possible explanations.

It is recommended that the activities be taught in sequential order. The skills acquired in one activity will be helpful in the subsequent activity.

Vocabulary

certainty	likelihood
explanation	observe
infer	observation
inference	

INSTRUCTIONAL PROCEDURE

Introduction

Place the gift-wrapped packages (see *Materials*) on the table in front of the children. Ask what kinds of things they can learn about a package by examining it without opening it. Record children's responses on a chalkboard chart such as Figure 1.

As you hold up one package, ask the children what they can tell you about this package. (Responses should be visual observations—size, shape, and so on.) Ask them what they would guess is inside the package. List several of the guesses which are reasonable considering the size and shape of the package. Ask the children if they are sure of their guesses. Suggest that they may wish to make more observations in order to get a better idea of what is in the package. Tell the children that a guess based on one or more observations is called an *inference*.

Divide the children into groups of five. Give each group a package and a copy of *What's Inside?* shown as Figure 1. Ask the groups to record their observations and to make inferences about the contents of the package. Be sure that inferences are stated in terms of likelihood, not certainty.

Have each group tell its inferences and then tell which observations make them think their inferences are correct. Ask the children if they have more confidence in these inferences or in the earlier guesses. Have them explain why. The children will probably have more confidence in the new inferences because they have more observations on which to base them. Have the children open the packages to check their inferences and let them eat the candy.

Materials

Packages, 6, gift-wrapped, each containing five dinner mints
What's Inside?, 1 spirit master, Figure 1 (*Module 33*)

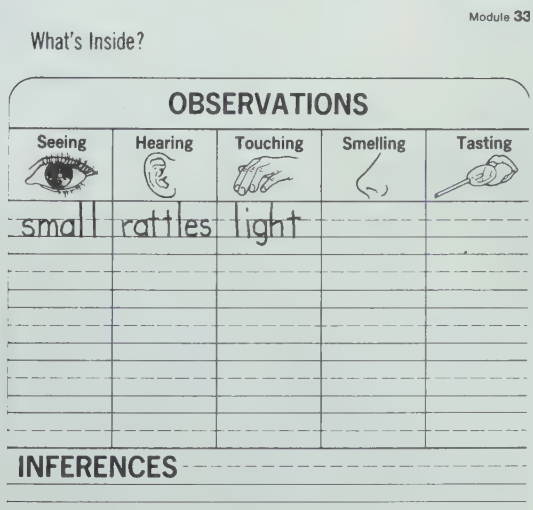


FIGURE 1

Activity 1

When the children are not watching you, fill three identical containers: one with white vinegar, another with water, and a third with light corn syrup. Label each with a numeral: *1*, *2*, and *3*. Place the containers in the room where the children can see them, but cannot touch or smell them.

Write these headings on the chalkboard:

Container *Observations* *Inferences*

Ask the children what they think is inside each of the containers. When a child answers, "Container 1 has _____ in it," ask if the answer is an observation or an inference. Record on the chalkboard the inference for Container 1 and ask why the child thinks the container has _____ in it. Ask if this response is an observation or an inference. Record his answer. As children make statements, constantly emphasize the difference between observations and inferences. For instance, if a child says, "It is vinegar," point out that the child has made an inference; if a child says, "It looks like vinegar," remind the child that he has made an observation. Proceed until at least one inference and one observation have been made for each container.

Ask the children how certain they are of their inferences. How could they become more certain? (By making more observations.) Divide the children into groups of five. Give each group three vials, each containing a sample from one of the three containers, and three copies of *What's Inside?* (see Figure 1). Ask the children to make and record their new observations and inferences about the contents of each vial. Encourage the children to make observations which require the use of all the senses. Tell them that they may use the sense of taste, because you know that the liquids are safe to taste. (See Figure 2.)

As the children work, circulate among the groups to check on their identifications of observations and inferences.

Materials

Containers, 3, 250-ml, clear plastic, with covers (*Module 33*)
Vinegar, 1 bottle, white (*Module 33*)
Corn syrup, 1 bottle, light (*Module 33*)
Vials, 18, 30-ml, clear plastic, with covers (*Module 33*)
What's Inside?, 1 spirit master, Figure 1 (*Module 33*)

Activity 2

Give each child a copy of the sheet *Observation or Inference?* (see Figure 3). Show the children a large sealed paper bag that has a ball in it. Tell the children that the statements on the sheet were made by children who were trying to find out what was in a similar closed paper bag. Have those children with sufficient reading skills complete the sheet independently. Ask them to share the magic pens (image developers). Have the remaining children work in a group with you. Read to the children the directions on the sheet. Then read each statement aloud, pausing after each for the children to mark their sheets. When the children have completed the sheets discuss their answers. Finally, let the group use the magic pens.

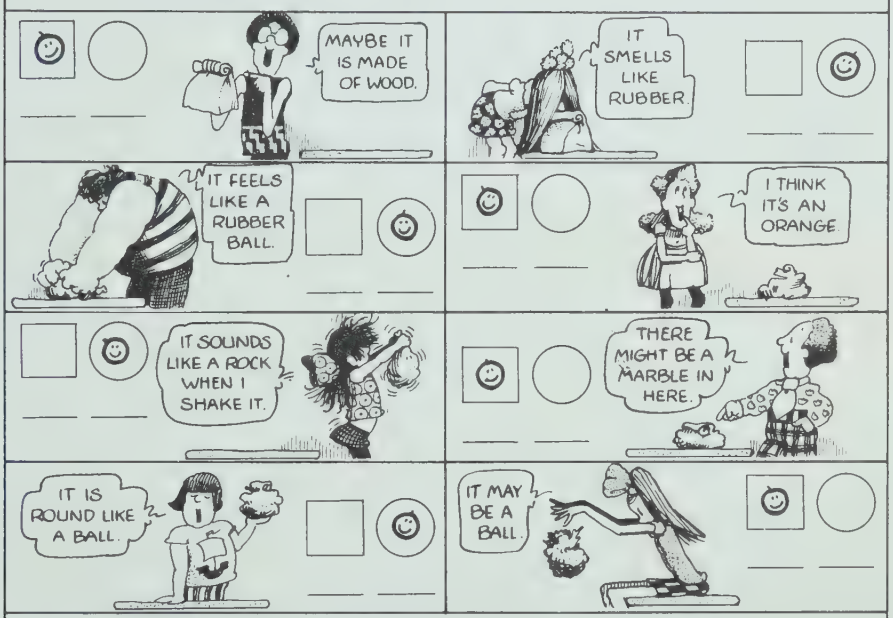
Materials

Observation or Inference?, 1 spirit master, Figure 3 (*Module 33*)
Paper bag, 1
Ball, 1 (*Module 40*)
Pens, 5, image developers (*Module 33*)

Module **33**

Observation or Inference?

With your pencil, put a ✓ on the line under the □ if you think the person is making an inference. If you think the person is making an observation, put a ✓ on the line under the ○.


MAYBE IT IS MADE OF WOOD.
IT SMELLS LIKE RUBBER.
IT FEELS LIKE A RUBBER BALL.
I THINK IT'S AN ORANGE.
IT SOUNDS LIKE A ROCK WHEN I SHAKE IT.
THERE MIGHT BE A MARBLE IN HERE.
IT IS ROUND LIKE A BALL.
IT MAY BE A BALL.

When you are finished, get a magic pen and fill in the shape above your check ✓. If you are right, a smile ☺ will appear!

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FIGURE 3

Activity 3

Give each group of five children two identical, closed milk cartons: Carton 1 filled with water and Carton 2 filled with tissue paper. Allow the children to examine but not open them. Have each group list their observations and inferences about Carton 1 and Carton 2 on a copy of *What's Inside?* shown as Figure 1. Now have the children tell you their observations and inferences. List them on the chalkboard. One inference that the children will probably suggest is "Carton 2 *is* empty." Explain that the inference should suggest likelihood, not certainty. A few children may object to changing the inference to "Carton 2 *might be* empty;" they may express certainty that it *is* empty. Ask if they are sure. When they have committed themselves, have one child in each group open Carton 2 and pull out the tissue paper. Ask the children what inferences they can make about what is in the other carton. Ask what other observations might be helpful. After the children have made other observations and inferences about Carton 1, have a child in each group open the carton.

Materials

Milk cartons, 12, identical, from cafeteria
Tissue paper, 6 sheets
What's Inside?, 1 spirit master, Figure 1 (*Module 33*)

Generalizing Experience

Encourage the children to practice making inferences to explain observations. You might keep a paper or cloth bag in the room and from time to time put an object such as a ball, block, rock, or leaf into the bag. Have the children make observations about the object without looking into the bag, and then try to infer what the object is. To emphasize that an inference can only explain observations, you might ask if the children can infer what color an object is. The children should realize that since they cannot see the object, they cannot tell what color it is.

APPRAISAL

Ask each child to bring to school an object wrapped to conceal its identity. The object should be a common one, one that the other children have probably seen. Label each package with the child's name and collect the packages at the front of the room. It is a good idea to have a few packages ready in case some of the children forget to bring theirs.

Distribute the packages among the children so that no child has his own package. Also give each child a copy of *What's Inside?* shown as Figure 1. Have each child make as many observations as he can about the package he has and then make at least one inference about what is in it.

Divide the children into groups of five. Within each group, have each child share his observations about his package. The other children may make additional observations and should challenge the observations with which they do not agree. When each child shares an inference, the others should discuss whether or not the inference is an explanation of all the observations. Finally, the child who is presenting observations and inferences may open the package. Since inferences will often be "wrong", this activity will again emphasize the idea that inferences should be made in terms of what the object "probably is," "might be," or "is likely to be," and so on.

Materials

Packages, 1 for each child, each concealing an object brought from home
What's Inside?, 1 spirit master, Figure 1 (*Module 33*)

COMPETENCY MEASURE

TASK 1 (Objective 1): Give the child a sealed box which contains a rock. Say, **I am going to read three statements about the box. Tell me whether each statement is an observation or an inference.**

1. **The box is heavier than a pencil.** (Observation.)
2. **The box probably has a golf ball in it.** (Inference.)
3. **Something inside rattles when I shake the box.** (Obsevation.)

The child should identify all three statements correctly.

TASK 2 (Objective 2): Say to the child, **Make as many observations as you can about the sealed box.** When the child has done this, say, **Make an inference about what is inside the box. How certain are you about this inference?** The child should state his inference in terms of what the object "probably is," "might be," "could be," "is likely to be," and so on.

Materials

Box, 1
Rock, 1

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33 Inferring/a

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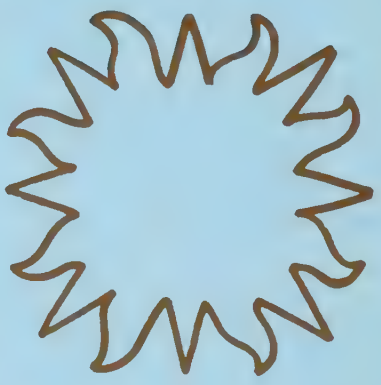

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MODULE

34

Measuring/e

About How Far?

OBJECTIVES

At the end of this module the child should be able to

1. *CONSTRUCT* estimations of linear dimensions of common objects in terms of centimeters, decimeters, or meters.
2. *IDENTIFY* a known object that is approximately the same length or width as another object.

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SEQUENCE

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RATIONALE

During all of the previous modules emphasizing measurement, the children compared an object directly with a standard, or arbitrary, unit. At times, however, such measuring by direct comparison may not be possible without special techniques, or it may not be necessary because of the way the measurements will be used. In such cases, an estimation is often satisfactory. In this module, children make estimations by comparing a length to be measured with a mental image of a standard unit.

Estimating is a skill that requires a familiarity with a measuring system. In turn, practice in estimating leads to greater facility in the use of this measuring system.

It is reasonable to expect that estimates of measurements that are ten units or more should be accurate within two units. For example, if the width of a table is 1 meter, or 10 decimeters, then a satisfactory estimate is a value that falls between 8 and 12 decimeters. Estimates of measurements less than ten units should be accurate to within one unit. In general, the measured value of a given length plus or minus 20% of the measured value will yield a reasonable range of estimated values for the same length.

Vocabulary

estimate	compare
dinosaur	approximate (adjective)

INSTRUCTIONAL PROCEDURE

Introduction

To begin a discussion about estimation, ask the children if they would like to walk to ___ (a distant city) or if it is possible to stand on the ground and touch the top of a flagpole. The children will probably respond with a resounding "NO!" Then ask, "Why not?" When the children answer with statements such as "It is too far," or "It is too high," explain that even though they probably have never tried to measure such distances directly, they have just made an *estimate* of a measure of distance. In other words, they have estimated, or measured in their minds, the distance from one point to another point—the distance from the ground to the top of the flagpole, for example. Tell the children that making estimates can be fun and that in the following activities they will practice making estimates of distances in metric units.

Divide the children into small groups and give each group a meterstick. Have the children review the markings on the meterstick. Ask the children to use the meterstick to show you the length of a centimeter, a decimeter, and a meter. The children should mark off the three lengths along the meterstick by using their fingers. Have each child measure the width of a finger, and report the results. The children should discover that a finger is about 1 centimeter wide. If not, tell them the approximate measurement and have them measure again. Then have the children measure the distance from the tip of the middle finger to the heel of the palm; they should find that this length is approximately 1 decimeter. The children can then measure one child's "giant step," or pace. Again, let them make their own measurements before you tell them that the step should measure approximately 1 meter.

Ask all the children to estimate the height of their desks in decimeters, and then have two or three children measure that height with a meterstick. Next, ask all of the children to estimate one child's height in decimeters; for convenience, select a child who is about half as tall as the door is high. Then ask two or three children to measure that child's height. Have them compare the child's height with the height of the doorway. Ask the children if it is possible to estimate the height of the doorway in terms of the child's height. They should answer that the doorway is about twice the height of the child.

Point out that with a mental image of the child's height or the door's height, one can estimate the height of other objects without having to measure them.

Materials

Metersticks, 10 (*Module 34*)

Activity 1

Ask everyone to estimate some familiar distance such as that from the floor to the top of the chalkboard or bulletin board. Then have one of the children stand up; ask the other children to compare his height with the height of the room, which is probably about 3 meters. The room may be about three times the height of the child. Ask how tall the child is in meters or decimeters, and when several estimates have been made, measure the child's height. Ask the children if they can see or think of other objects that are about as high as the child. In other words, they are to use the height of the child as a visual reference for the estimation. Ask the group to estimate the height of something else in the room, for example, the distance from the floor to the top of the windows. After the children have offered several estimations, measure the height with a meterstick.

Suggest that the children estimate, in meters or decimeters, the height of something on the playground, such as the basketball hoop. You might ask questions such as the following: Is it as high as the door or higher? Could a child touch the top? Is it as high as the ceiling? Write the children's estimates on the chalkboard to show the range. Then take the children outside to measure the height directly and see how close their estimates are.

The children should repeat the activity by estimating heights of familiar objects such as a car, a bike, and a baseball bat, and then checking the accuracy of their estimates.

Next, ask the children to estimate the width in meters of places such as the playground, the schoolroom, and the school stage. Establish a horizontal object of reference for these (a tabletop 2 meters long, for example), since a vertical object may not make the same visual impression when it is seen horizontally as when it is seen vertically.

Materials

Metersticks, 10 (*Module 34*)

Activity 2

Ask one child to extend an arm horizontally out from his side. Have several children make estimates of the length in decimeters from the child's chin to the tips of his fingers. Write the estimated lengths on the chalkboard. Two children should then measure the actual length, and the others should compare this measurement with the estimates. Now tell the children to compare this fingertip-to-chin length with the dimensions of objects in the room, such as the width of the door opening or the height of the desk.

Then ask a child to extend both arms horizontally out from his sides and ask the other children to estimate how this length compares with that of other objects or with the child's height. Then have them make the measurements to check their estimates. For most people, the distance across extended arms is very close to the individual's height.

Ask each child to estimate in centimeters the widest spread of his fingers, from the tip of his thumb to the tip of his little finger. Then have the children measure this length by placing their hands on a metric ruler or a meterstick.

Materials

Metersticks, 10 (*Module 34*)
Rulers, 30, metric (*Module 34*)

Activity 3

The children are now prepared to play the *Estimation Game*. There are two versions, indoor and outdoor, and all of the children should have the opportunity to play both. The game can be played by an individual, but it will be more challenging if two children play it together. The indoor version should probably be played first, since it is more easy to supervise than the outdoor version. The indoor version can be played on either a smooth or a carpeted floor. Give the children the following information about materials needed and the rules of the game.

Materials for the Estimation Game

Indoor Estimation
3 bases (metal washers)
1 playing piece for each player
1 meterstick
1 scorecard (piece of paper) for each player
Outdoor Estimation
3 bases (hula hoops, bowling pins, or cardboard squares)
1 playing piece (flying-saucer toy, soccer ball, or beanbag) for each player
1 10-meter rope marked off in 1-meter lengths with masking tape or marking pen
1 scorecard (piece of paper) for each player

Indoor Estimation is set up by placing the three bases 5 to 10 decimeters apart so that they form an equilateral triangle. Each player needs a playing piece and a scorecard; each pair of children needs one meterstick to check estimations of distances.

The first player begins the game by placing a playing piece next to one of the bases. The second player puts his finger alongside the piece to mark its position. The first

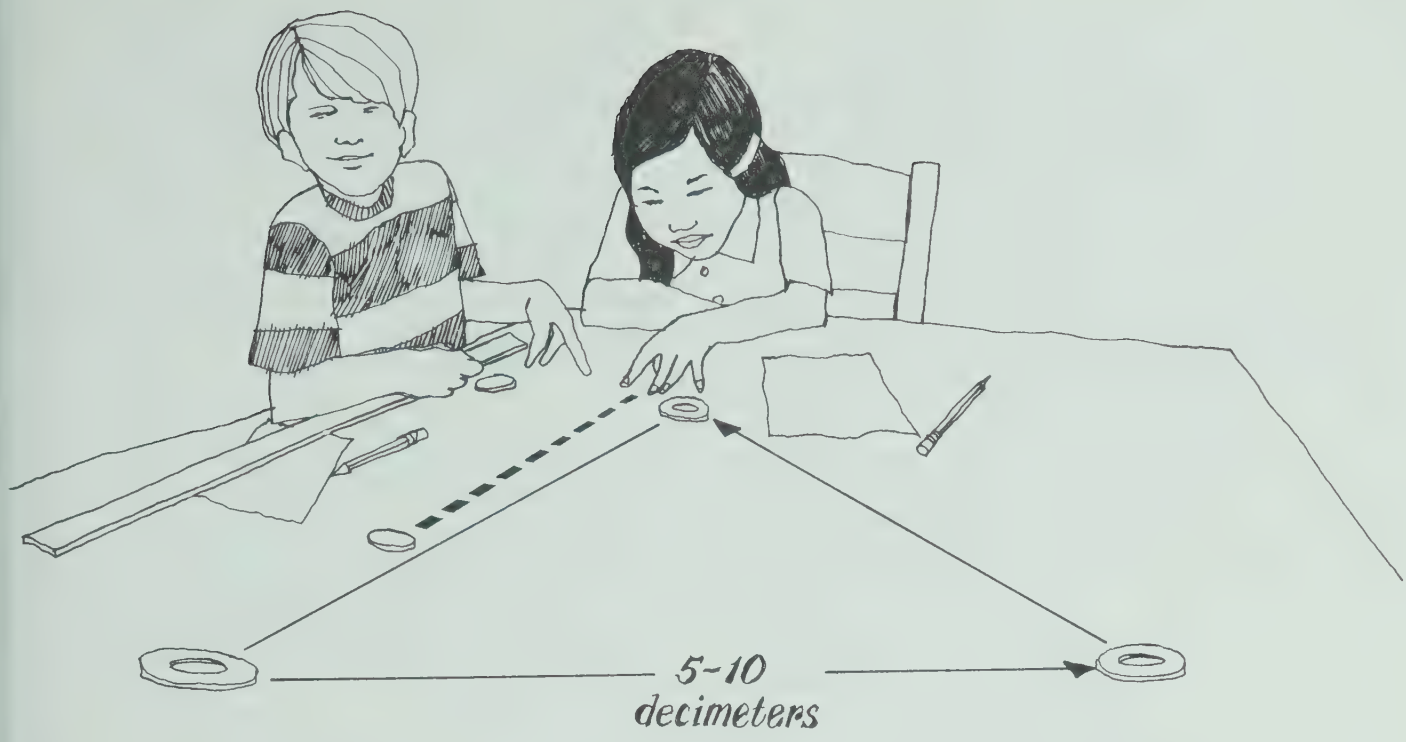

FIGURE 1

player then moves the piece toward one of the other bases by giving the piece a quick push or flick with his finger. (See Figure 1.) He records a move on his scorecard and then estimates the distance in centimeters or decimeters from the starting point of the piece, where the second player's finger is, to its position after the move. He then measures the distance with the meterstick. If his estimation was within the acceptable range (see *Rationale*), he moves again toward the target base. If the estimation was not within the acceptable range, the second player takes his turn, with the first player assisting.

Play continues until each player has moved around the triangle, touching each base in turn. (See Figure 1.) The winner is that player who moves around the triangle in the smaller number of moves. The game may be played by an individual rather than by two players, if the child marks the position of the playing piece before each flick, so that he can accurately measure the distance the piece travels.

The outdoor version is played by the same rules as the indoor game. The bases are placed in a triangular array 5 to 10 meters apart, depending upon space available. Hula hoops can serve as bases, and flying-saucer toys, balls or beanbags can be thrown as playing pieces. Alternatively, children might throw beanbags—or kick soccer balls—at bowling-pin bases. A 10-meter length of heavy string marked at 1-meter intervals can be used to check the estimates quickly.

Once the children learn the game they should be encouraged to play it with their families and friends outside of school. Estimations can be made in terms of paces and checked by actually pacing the distance, but it is preferable for the children to practice estimating in metric units.

Materials

Washers, 30, metal (*Module 34*)
Playing pieces, 30 disks (*Module 34*)
Metersticks, 10, or metric rulers (*Module 34*)
Scorecards, 1 piece of paper for marking score for each child
Pencils, 1 for each child
Hula hoops, 3 for each game, or bowling pins, or cardboard squares
Flying-saucer toy, 1 for each player, or soccer ball or beanbag
Heavy string (*Module 34*)
(Note: Cut the string into 10-m lengths. Mark off each length into 1-m segments.)
Masking tape, 1 roll

Activity 4

Show the children a picture of a *Brontosaurus* (see Figure 2). Point out that *Brontosaurus* is a *dinosaur*, and briefly explain that dinosaurs are extinct reptiles that lived millions of years ago before any people existed; many dinosaurs were very large, and at one time they were the major form of animal life on Earth. Ask the children how long they think this dinosaur was. After they have made some guesses, say that *Brontosaurus* was about 20 meters long. Discuss this length and ask what it can be compared with. Tell the children to observe the length of the room, for example. Have the children estimate this length and then measure it. Tell them next to observe the width of the room and then to estimate and measure it. Compare the length of a 20-meter *Brontosaurus* with the length and width of the room. Ask questions such as these: Could a *Brontosaurus* fit lengthwise into this room? In two rooms? In three rooms?

Now show the children a picture of a *Tyrannosaurus rex*. (See Figure 3.) Tell them that this dinosaur's height was about 6 meters. Tell them to observe the height of the room. Then have them estimate, measure, and compare the height of the room with the height of *Tyrannosaurus rex*.

The children may find it interesting to draw a full-size dinosaur with washable paint or chalk on a suitable surface such as a road or playground.

Ask the children to estimate the sizes of pets such as dogs, cats, birds, turtles, guppies, or tropical fish. Have the children compare the length or height of their pets with the dimensions of objects in the room. Having actual animals in the room, or showing life-size pictures of animals, will add to the interest of the lesson as well as assist the children in making the estimates. Suggest that the children ask their parents' help if necessary in checking their estimates of pets' sizes.

Materials

Picture cards, 2, one of a *Brontosaurus* and one of a *Tyrannosaurus rex* (*Module 34*)
Metersticks, 10 (*Module 34*)

Generalizing Experience

Ask the children to draw a picture of a large object, such as a tree, with a car or a person beside it for a size comparison. Then ask how high the tree is compared to the car or person; for example, the tree might be as high as four cars.

Materials

Paper, 1 sheet for each child
Crayons, 1 box for each child

FIGURE 2

FIGURE 3

APPRAISAL

Stretch 3 meters of ribbon, yarn, or masking tape on the floor or on the edge of the chalkboard. Fasten it so that it remains taut. Have each child write the numerals 1 through 8 on a sheet of paper. Ask them to write *yes* if the statement you read is correct and *no* if the statement is wrong. Then read the following statements, filling in the necessary information about the lengths of the reading book, teacher's desk, and windowsill. Give the children time after each statement to move around and examine the available objects.

1. The (ribbon, tape, or yarn) is about twice as long as the distance from the floor to the top of the window.
2. The (ribbon, tape, or yarn) is about the same length as three of your desks placed side-by-side.
3. We have to go only 200 centimeters to get from this study area to the playground.
4. A robin is about 40 decimeters long.
5. Our reading book is about ___ (measured length) centimeters wide.
6. The teacher's desk is about ___ (measured length) decimeters long.
7. The table is 7 meters long.
8. The windowsill is about ___ (measured length) meters long.

Materials

Masking tape, 3-m strip, or ribbon or yarn
Writing paper, 1 sheet for each child
Pencils, 1 for each child

COMPETENCY MEASURE

TASK 1 (Objective 1): Hand the child an unused crayon. Say, Estimate the length of this crayon in centimeters. The child's estimate should be within 2 centimeters of the actual length.

TASK 2 (Objective 1): Say, Estimate my height in decimeters. The child's estimate should be within 2 decimeters of the actual height.

TASK 3 (Objective 2): Hold up this instructional booklet, which measures about 21.5 x 28.0 centimeters. Say, Show me something that is about the same length or width as the width of this booklet. (Point to the dimensions of the booklet as you say this.) The child should show you something having a dimension that is within 4 centimeters of the width of the booklet.

TASK 4 (Objective 2): Show the child a meterstick. Say, Show me something that is about the same length as this meterstick. The child should show you something that is between 8 and 12 decimeters long.

Materials

Crayon, 1 unused
Meterstick, 1 (*Module 34*)

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MODULE

35

Using Space/Time Relationships/f

Symmetry

OBJECTIVES

At the end of this module the child should be able to

1. *IDENTIFY* objects that have line or plane symmetry.
2. *DEMONSTRATE* that some objects can be folded or cut in one or more ways to produce matching halves.
3. *IDENTIFY* and *DESCRIBE* bilateral symmetry.

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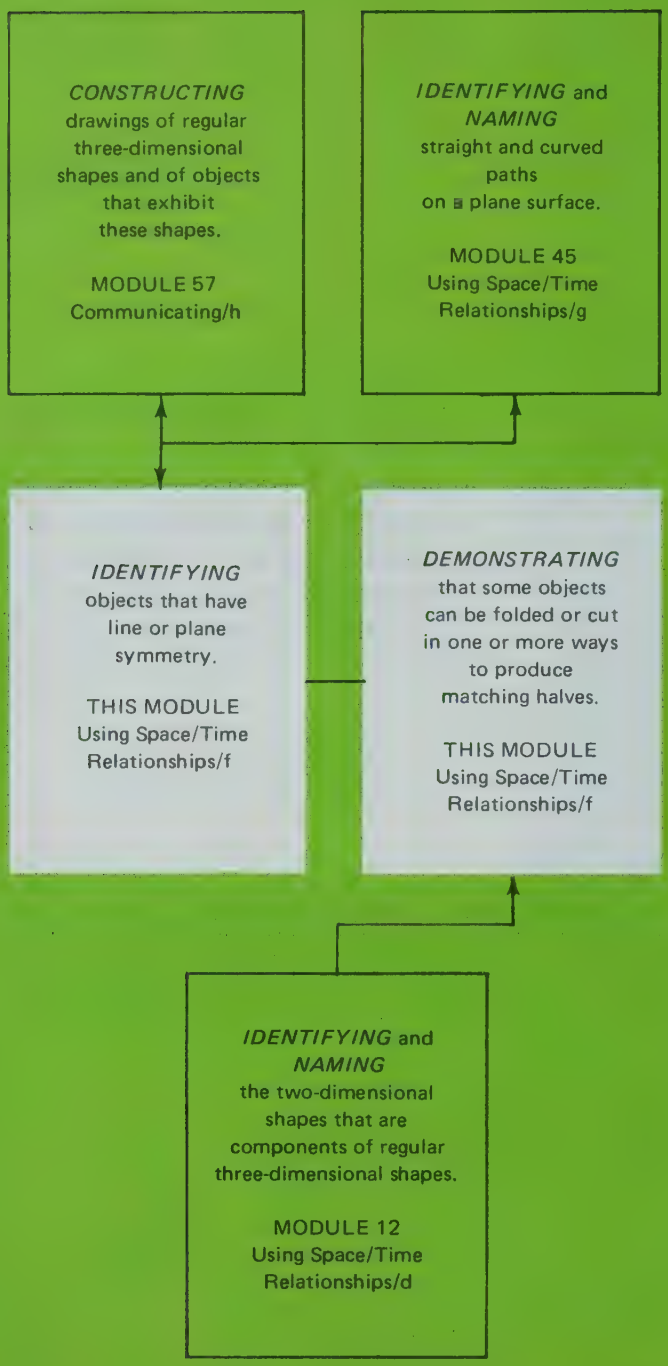
CONSTRUCTING drawings of regular three-dimensional shapes and of objects that exhibit these shapes.
MODULE 57 Communicating/h
IDENTIFYING and *NAMING* straight and curved paths on a plane surface.
MODULE 45 Using Space/Time Relationships/g
IDENTIFYING objects that have line or plane symmetry.
THIS MODULE Using Space/Time Relationships/f
DEMONSTRATING that some objects can be folded or cut in one or more ways to produce matching halves.
THIS MODULE Using Space/Time Relationships/f
IDENTIFYING and *NAMING* the two-dimensional shapes that are components of regular three-dimensional shapes.
MODULE 12 Using Space/Time Relationships/d

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

Having become familiar with some common two-dimensional and three-dimensional shapes in previous modules, the children are ready to observe a certain property of these shapes—symmetry, or lack of it. The recognition of this property is helpful in describing and classifying physical and biological objects in our environment. For example, the presence or absence of symmetry can be observed among plants, animals, and crystals.

Symmetry of an object, as the term is used in this module, may be defined as the repetition in size, form, and arrangement of parts on opposite sides of a line or plane. In circles, squares, spheres, and cubes, each part is exactly matched on opposite sides of a line or plane of symmetry. In certain plants, animals, and crystals, although the repetition of parts is not exact, it is often so close that we consider them symmetrical.

In speaking of inexact geometrical shapes, have the children take special care to use such statements as, "This animal's body has a shape like an ellipsoid," or "It *looks like* a rectangle in outline." Also have them avoid misleading and incorrect statements. For example, instead of saying, "This head *is* a sphere," they should say, "This head is shaped *like* a sphere."

In many cases, two-dimensional shapes can be folded so that one half has a point-for-point correspondence with the other half. The line along which the shapes are folded to produce matching halves is called a line of symmetry. A square has four of these lines, a rectangle has two, and a circle has an infinite number. (See Figure 1.) Thus, one way of classifying two-dimensional shapes might be based on the number of lines of symmetry.

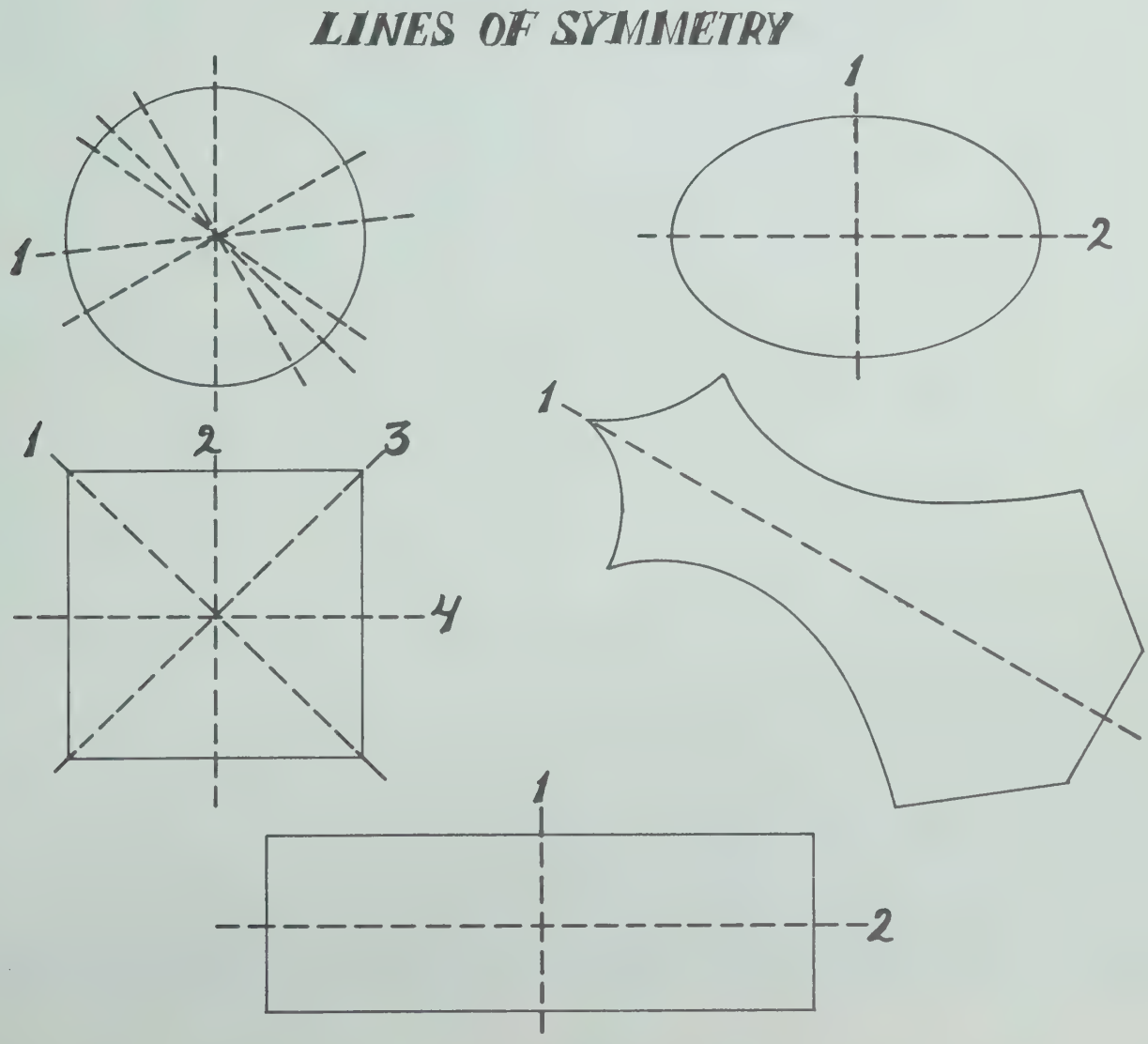

FIGURE 1

With three-dimensional objects, the corresponding idea is that of a plane of symmetry. If a plane exists along which the object might be cut to produce point-for-point correspondence between the two halves, the object possesses plane symmetry. The object is thus symmetrical with respect to this cutting plane. (See Figure 2.)

Many of the regular shapes the children know have several (or in the case of spheres, infinitely many) planes of symmetry. In this module, the children will discover that most vertebrates have bilateral symmetry, that is, only one plane of symmetry, although the two parts may not match exactly.

Frequently, teachers request suggestions that can reinforce process learning beyond the science curriculum. Several specific suggestions are included in the *Generalizing Experiences.*

Vocabulary

symmetry	plane of symmetry
symmetrical	bilateral symmetry
line of symmetry	

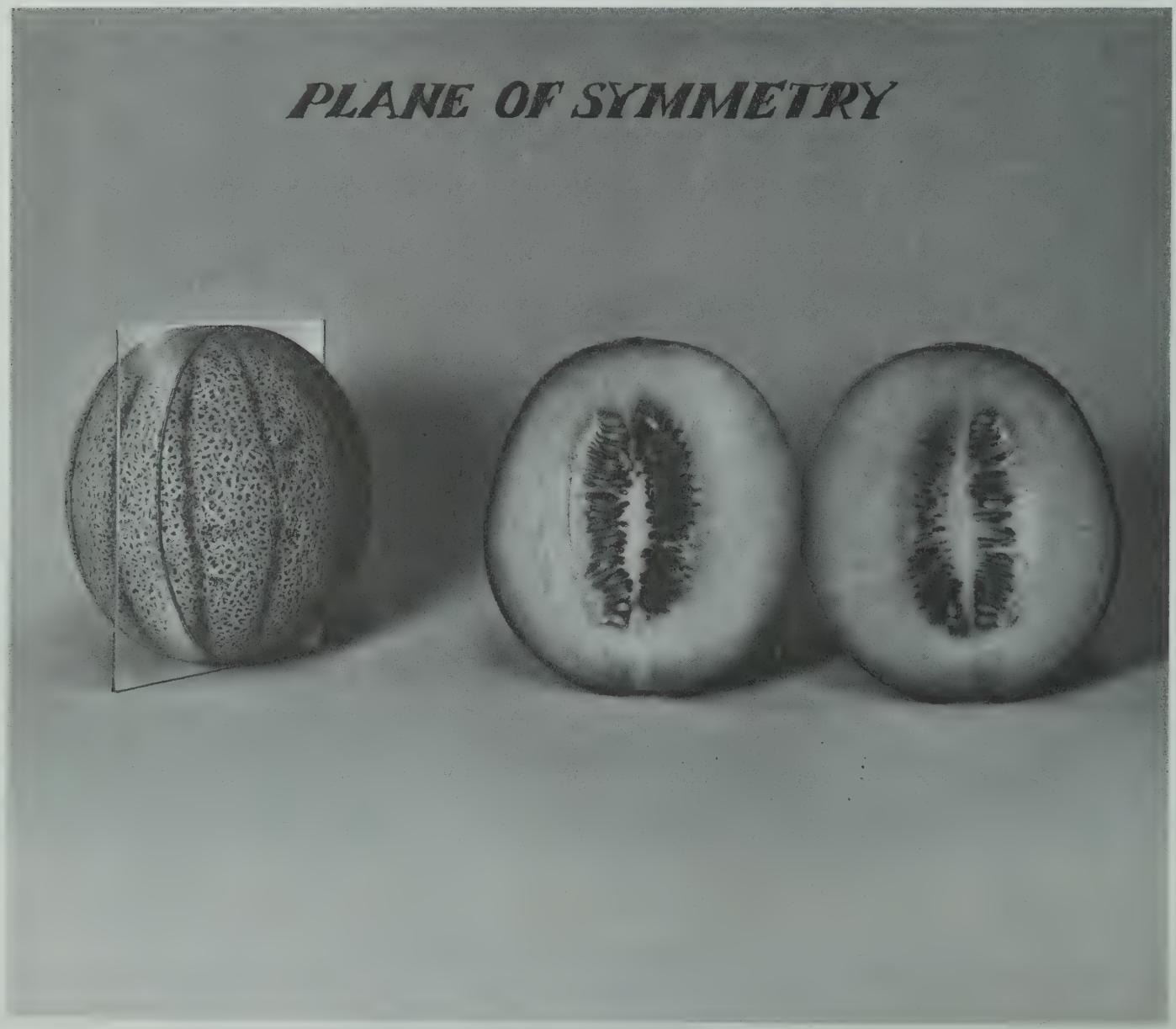

FIGURE 2

INSTRUCTIONAL PROCEDURE

Introduction

Show the class two displays that you have prepared beforehand on posters or on a bulletin board. One display should consist of symmetrical shapes pinned or otherwise fastened to it. You can easily make the shapes by folding a sheet of paper, cutting half of the shape, and then unfolding the paper. Many of these shapes will be familiar to the children. The other display should include cutouts that are not symmetrical. Have everyone watch as you cut out a few more shapes and add them to each display. As you do this, ask the children if they know the basis by which the shapes have been separated into two displays, or how the displays are different.

If the cutouts in one display are alike in other characteristics besides symmetry or lack of symmetry, the children may think that you have classified them on the basis of these other characteristics. For example, if the smaller shapes are all on one poster, the children might say that the separation is on the basis of size. If so, put an even smaller shape on the other display. If several cut-outs of living things are together on the display with the symmetrical shapes, the children might suggest that living and nonliving things have been separated. If so, cut out a drawing of a nonsymmetrical tree, and put it on the "nonsymmetrical board."

With this type of help, the children should eventually recognize that the shapes in one group all have matching halves, whereas the shapes in the other group do not. The fold should be noticeable if you have fastened the symmetrical shapes with a tack in only one half of the shape. One of the children will probably say that some shapes have been folded and others have not. If no one comments on the folds, call attention to them by folding and unfolding a few of the shapes on the board, but saying nothing. If the children still do not notice the folds, then point them out.

Ask the children how the shapes have been folded, and encourage them to describe the folded shapes. Distribute several of the symmetrical shapes for the children to handle. Ask if the shapes in the other display could be folded this way. A few children may need to try folding the irregular shapes before they will understand the difference.

Point out that those shapes that are made up of matching halves are said to be *symmetrical,* or to have *symmetry*. Shapes that are not made up of matching halves are not *symmetrical*—that is, they do not have symmetry.

Materials

Shapes, symmetrical and nonsymmetrical

(Note: Cut out a variety of shapes that include familiar objects, living things, geometric figures, and letters of the alphabet. Each symmetrical shape should have a noticeable fold that separates the matching halves of the shape. You may wish to use as patterns the symmetrical geometric shapes and the symmetrical and nonsymmetrical capital letters provided for the children's use in *Activity 2* of this module.)

Activity 1

Give each child a copy of *Lines of Symmetry* (see Figure 3), and have the children cut out the squares along the solid lines, as neatly as possible. Demonstrating as you give the instructions, have each child fold the square along any of the dotted lines so that it is divided into matching halves. Ask a child who chose line number 2 or line number 4 to hold up the folded square and explain why it shows matching halves. Suggest that the children call the line along which the figure is folded the *line of symmetry*. Have another child show one of the diagonal folds (lines 1 or 3) and explain whether or not that is a line of symmetry—that is, whether or not the square has matching halves when folded along that line.

Now have everyone cut out the rectangles. Ask the children to fold their rectangles along one of the dotted lines. Then ask individual children to show each type of fold, and to tell whether the paper shows matching halves. Have the child who explains the diagonal fold tell how it differs from the diagonal fold on the square. For the rectangle, the fold does not result in halves that lie one on top of the other. The corners and edges of the halves do not match as they do in the square. Therefore, the diagonal lines of a rectangle are not lines of symmetry.

The children should be able to answer such questions as the following.

How can you tell if a shape is symmetrical? (It can be folded to produce matching halves.)

What do we mean by "matching halves"? (The corners and edges of the halves match.)

Are both the square and rectangle symmetrical?

Do both the square and rectangle have symmetry? (Yes.) As long as a shape can be folded to produce matching halves, it is said to have symmetry. The description of the symmetry varies with the shape. The child needs to recognize only that folding to produce matching halves indicates symmetry about the folding line.

How many lines of symmetry does a square have? (Four.)

How many lines of symmetry does a rectangle have? (Two.)

In how many ways can you fold a rectangle to produce matching halves? (Two.)

Materials

Lines of Symmetry, 1 spirit master, Figure 3 (*Module 35*)
Scissors, 1 for each child

Activity 2

Give each child a set of geometric shapes and capital letters (see *Materials*). (It is not expected or necessary that the children know the names of all the shapes.) Have everyone separate, or classify, the shapes and letters into two groups: those that are symmetrical and those that are not symmetrical. Ask the children to try to agree on the classification of each shape and letter without folding it. Find those shapes about which the children disagree, and ask the children to test for symmetry by folding them. Because some children are unable to fold evenly, you may find it necessary to fold the cutout yourself—but do so at the child's direction.

Introduce the following activity here, or later as a *Generalizing Experience*, whichever seems more appropriate. Ask the children to group the symmetrical shapes further, according to the greatest number of ways each shape can be folded to produce matching halves: (1) in only one way (heart and quadrangle); (2) in two ways (rectangle); (3) in three ways (equilateral triangle); (4) in four ways (square and ellipse); and (5) in more than four ways (circle and star). Encourage the children to use the same method to group the capital letters.

Materials

Shapes, symmetrical, die-cut paper, circles, rectangles, squares, hearts, ellipses, stars, equilateral triangles, and quadrangles (*Module 35*)
Capital letters, die-cut, A through Z (*Module 35*)

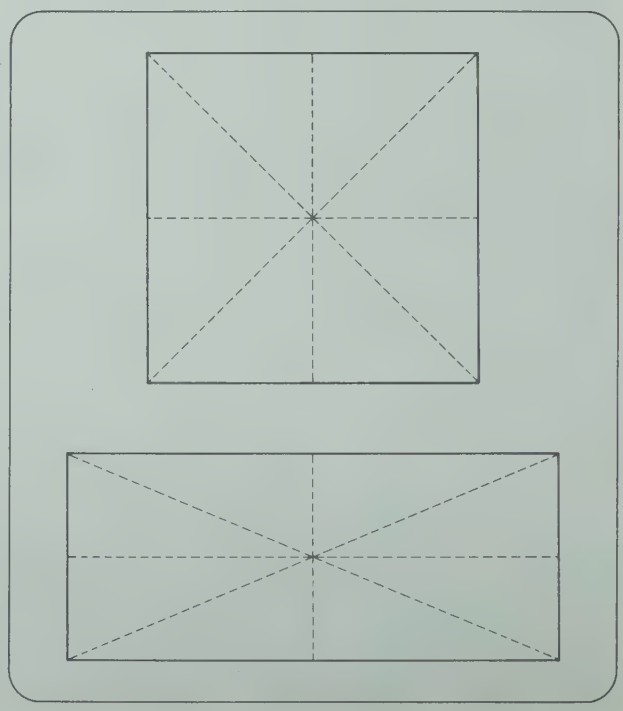

FIGURE 3

Activity 3

Because many young children have difficulty in identifying the symmetry of three-dimensional objects, it is often helpful to approach this problem with the aid of two-dimensional drawings of three-dimensional objects. Distribute to each child a copy of *Planes of Symmetry*. Ask the children to draw a line that cuts the picture of the apple into two matching halves. Ask them to do the same for the pictures of the pear, the pineapple, and the carrot. Then have the children cut out the pictures and fold each cutout along the line of symmetry that each child has drawn. Cut out the pictures for those children who have difficulty, but ask them to fold the cutouts themselves.

Now divide the children into groups of two or three. Give each group a suitable fruit or vegetable (see *Materials*) and paper towels. Have each group decide where to cut the fruit or vegetable in order to divide it into matching halves. (See Figure 4.) Move from group to group cutting according to the children's instructions. After cutting the fruit or vegetable for each group, discuss with all of the children the results of each cut, calling attention to cuts that were made along a *plane of symmetry* and to cuts that were not. If the cut was not made along a plane of symmetry, ask the children how the piece might have been cut to produce matching halves. Ask the children to identify the number or planes of symmetry each fruit or vegetable has.

Materials

Planes of Symmetry, 1 spirit master (*Module 35*)
Pencils or crayons, 1 for each child
Scissors, 1 for each child
Fruits or vegetables, 15, such as apples, pears, pineapples, carrots, and bananas
Paper towels
Knife, 1, sharp, for teacher to cut fruit

FIGURE 4

Put three-dimensional symmetrical shapes on a table. The children may need a review of the names of these shapes. Ask a child to select one of the shapes, and to demonstrate its symmetry by the motion of his hand in the direction of the plane of symmetry. (See Figure 5.) The larger the models the more visible the demonstrations. Pursue the discussion of the symmetry of these shapes as long as everyone is interested. If a shape has several planes of symmetry, have the children identify the various planes.

Despite their experience with cutting fruits and vegetables in *Activity 3*, some of the children will almost certainly have difficulty in visualizing the cuts by which symmetry can be demonstrated. It might be helpful to these children if you cut a clay or plastic foam model of one of the shapes, to demonstrate planes of symmetry. To show symmetry in a rectangular solid, you might tape two cubes together and then cut the tape. To demonstrate the symmetry of a sphere, you might cut an inexpensive rubber ball.

Ask the children if people have symmetry and how they could demonstrate this symmetry. Allow the children to express their ideas as extensively as they wish. After some time, or if the children offer no workable ideas, tape a piece of string from the wall to the floor in such a way that a child or a chair can be placed behind it. (See Figure 5.)

Place a chair so that the string lies along the chair's plane of symmetry, and have the children observe the chair from directly in front of the string. Ask if there is any other way to place the chair behind the string to mark other symmetrical halves. After a few minutes of trial and error, it should become evident that the chair has only one plane of symmetry. Tell the children that an object that has only one plane of symmetry has *bilateral symmetry*.

If the children did not earlier demonstrate that people have only one plane of symmetry, divide the children into groups of three or four. Help the groups set up strings from the wall to the floor so that the children can determine for themselves how many planes of symmetry each member of the group has.

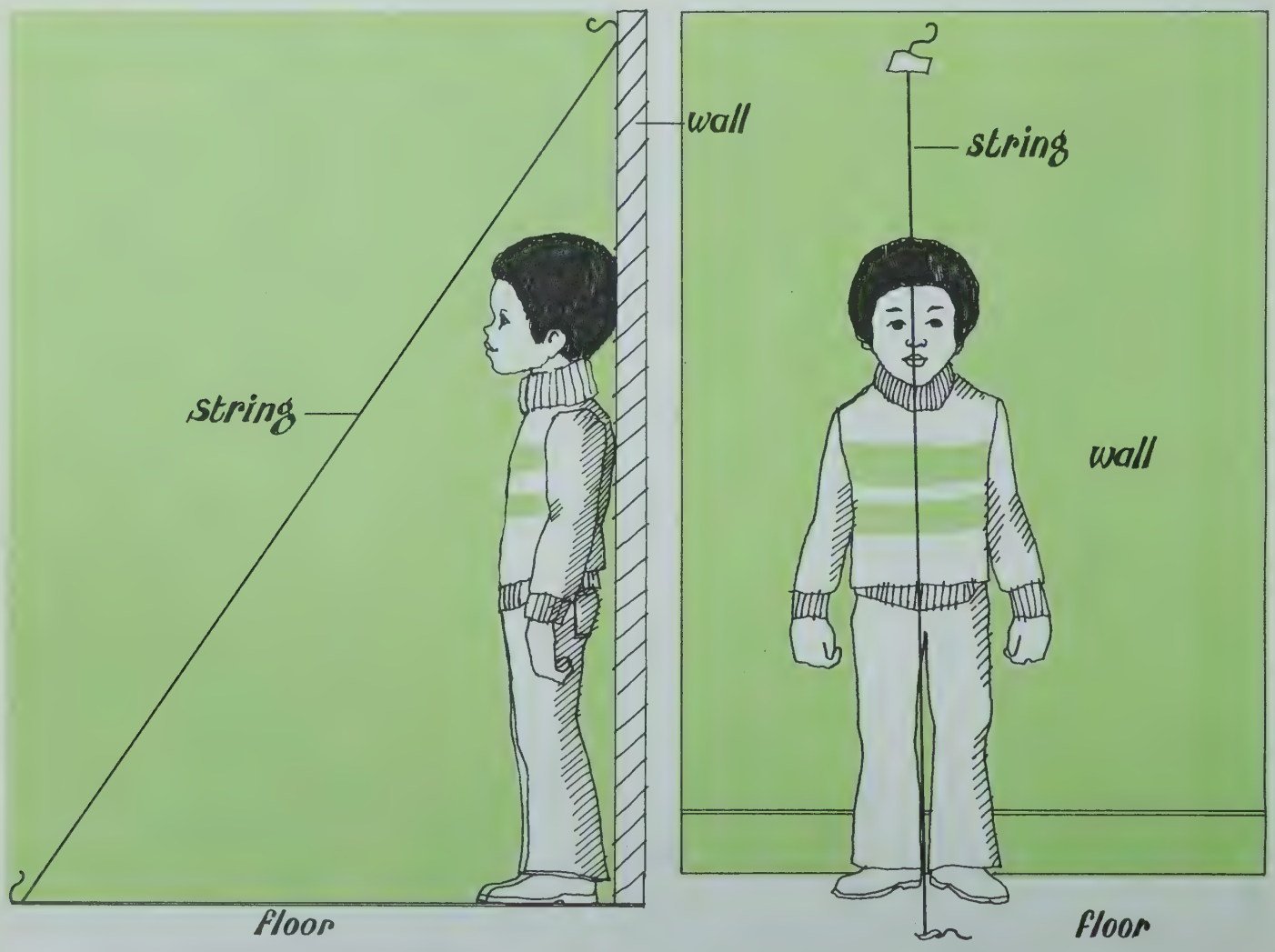

FIGURE 5

Ask the children to bring stuffed animals from home to determine the number of planes of symmetry the animals have. After the children have investigated the problem, ask such questions as the following.

Are people symmetrical? (Yes.) Are the stuffed animals?

How do you know? (They have planes of symmetry.)

How many planes of symmetry did you find for each person or stuffed animal? (One.)

What kinds of symmetry do people and other animals have? (Bilateral symmetry.)

How do you know? (They have just one plane of symmetry.)

To extend the activity, you might give each child a rectangular sheet of paper, and ask the children if they know how to make paper airplanes. If some of the children know how, have them demonstrate the method to the class. The correct folds are indicated in Figure 6. Encouraging the children to contribute their ideas, discuss the need for exact folding. Examine the airplanes for lines of symmetry. Have the children make a nonsymmetrical airplane. Let the children fly them outdoors. Afterwards, discuss what happened when the children tried to fly the two kinds of airplanes. Talk about real airplanes and have pictures and models available. Ask if real airplanes are symmetrical, and if so, in how many ways.

Materials

Shapes, 7, 3-dimensional (*Module 35*)
Clay, plastic foam, cubes taped together, or rubber ball and knife to illustrate planes of symmetry (optional)
Cubes, 2, 3-cm (*Module 35*)
String, 1 ball (*Module 35*)
Chair, 1, having bilateral symmetry
Stuffed animals, several, brought from home
Paper, rectangular sheets, to make airplanes (optional)
Airplane models and pictures (optional)

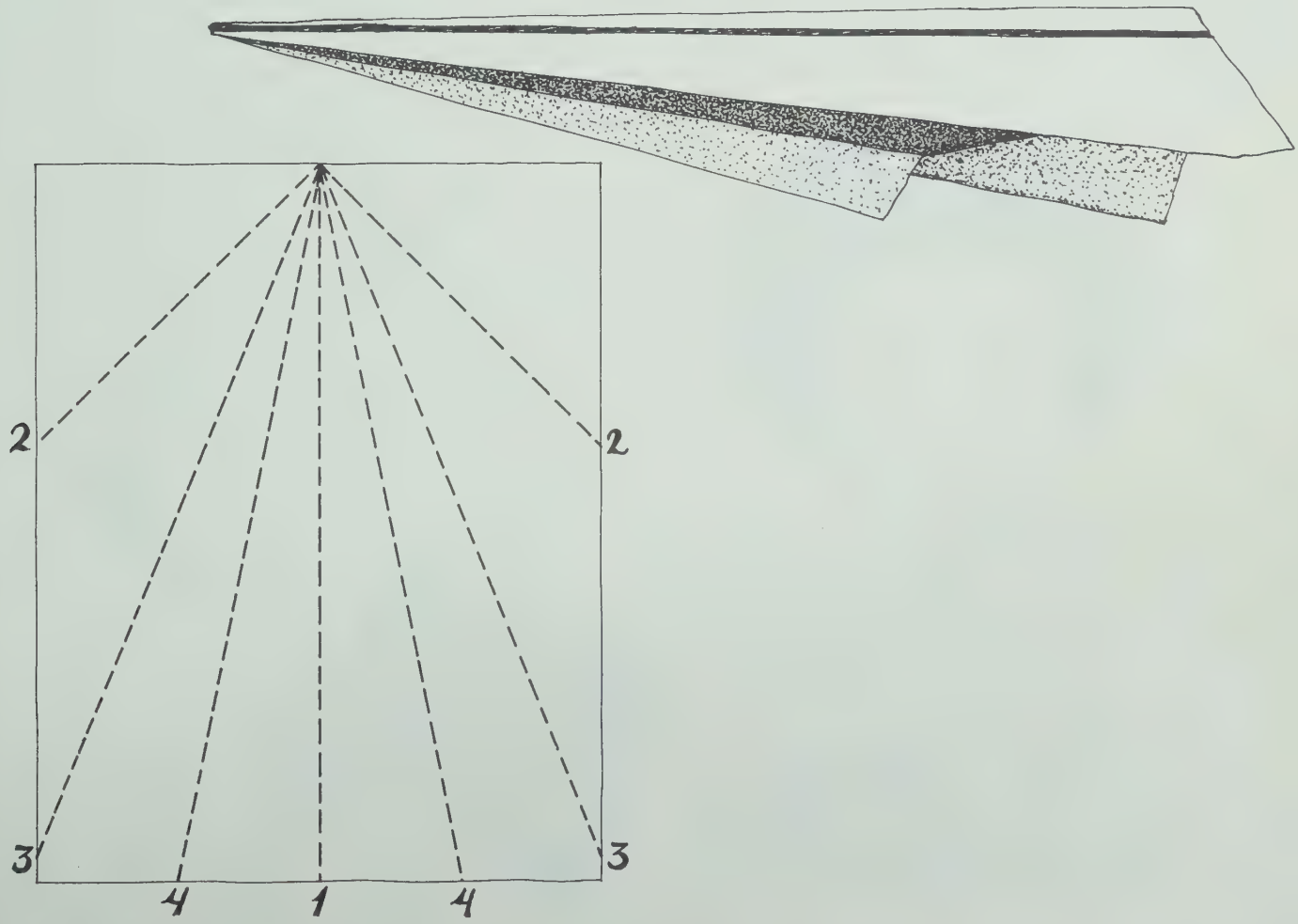

FIGURE 6

Generalizing Experiences

Take the children out-of-doors to find two- and three-dimensional shapes in the environment. Trees, grass, leaves, flowers, buildings, parts of sidewalks or fences, smokestacks, and so on represent various shapes and often have symmetry. For each item the children locate, have them name the type of shape they see. Then ask them if the item is symmetrical. Have the children tell you whatever they can about the symmetry, or nonsymmetry, of each item discussed.

As an art activity, give the children plasticene or modeling clay. Have the children make imaginary animals from the various three-dimensional shapes they know. The children should be able to discuss the animals' symmetry, or lack of symmetry. If some of the animals are not symmetrical, ask how the children could make them symmetrical.

Another art activity might be as follows. Give everyone a sheet of colored paper. Ask each child to fold the paper into two matching halves. Then have them cut out any shape they wish, as long as cutting begins and ends at different places on the folded edge. (See Figure 7.) Ask the children to open their cutouts, decide if each cutout is symmetrical, and, if so, draw the line of symmetry. Have the children examine both halves of the cutouts to see whether the halves have symmetry. All shapes cut out by this method will, of course, have at least one line of symmetry. Ask if any cutouts have more than one line of symmetry. Have the children prepare a bulletin-board display of the shapes they have made.

Playtime activities might include: identifying symmetrical toys; making symmetrical patterns with the interlocking pieces of a child's construction kit; analyzing symmetry in the classroom's floor plan and/or furniture arrangement; building a model of a symmetrical village; and finding shapes and symmetry in copies of art prints.

Materials (Optional)

Plasticene or modeling clay
Colored paper, 1 sheet for each child
Scissors, 1 for each child
Pencils, 1 for each child
Toys
Construction kit
Art prints or pictures

FIGURE 7

APPRAISAL

Give each child a copy of *Does It Have Symmetry?* Show the children six shapes, both two- and three-dimensional (see *Materials* for suggestions). Have the shapes labeled with the letters A through F. As you hold up each shape, ask the children to decide whether the shape is symmetrical or not symmetrical, and to put a check mark in the appropriate column on their papers.

Ask several children to demonstrate the symmetry or nonsymmetry of the two-dimensional objects just shown to them. Have other children select the shape or shapes that have bilateral symmetry. Ask still other children to describe the bilateral symmetry in the shape or shapes.

Materials

Does It Have Symmetry?, 1 spirit master (*Module 35*)
Pencils, 1 for each child
Shapes, 6, two- and three-dimensional, such as a pen, a chalk box, a dollar bill, a mug with handle, a nonsymmetrical design cut from paper, and a book or magazine; each labeled with a letter, A through F.
Scissors, 1 for each child

COMPETENCY MEASURE

For *Tasks 1* and *2*, show the child the picture card showing three shapes.

TASK 1 (Objective 1): Say, Choose those shapes that are symmetrical. The child should select all three shapes. If he chooses all but one shape, point to that shape and ask, Is this one symmetrical? Ask this question only once.

TASK 2 (Objective 2): Say, Show me how you could test these shapes to be sure that they are symmetrical. The child need only indicate a line of symmetry where each shape could be folded. The child should indicate a correct fold for each shape. In Figure 8, dotted lines indicate the correct folds.

TASK 3 (Objective 3): Say to the child, Show me one of the shapes that has bilateral symmetry. Explain how you can tell. The child should select either shape having bilateral symmetry (see Figure 9), and explain satisfactorily that the shape has only one line of symmetry.

Materials

Picture card, 1, showing three shapes (*Module 35*)

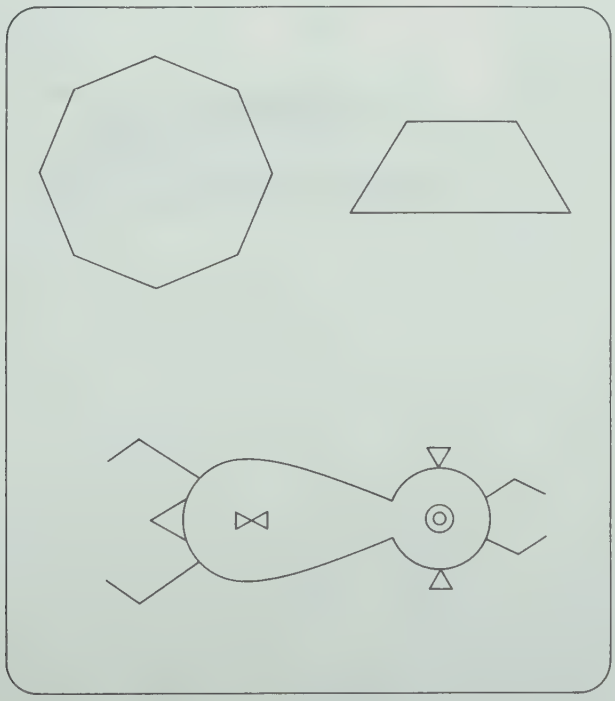

FIGURE 8

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35 Using Space/Time Relationships/f

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MODULE
36

Observing/1

Animal Responses

OBJECTIVES

At the end of this module the child should be able to

1. *DESCRIBE* the kinds of locomotion characteristic of animals having various shapes and appendages.
2. *IDENTIFY* an animal's response to an identified stimulus.
3. *DESCRIBE* a stimulus-response situation in the environment of an animal.

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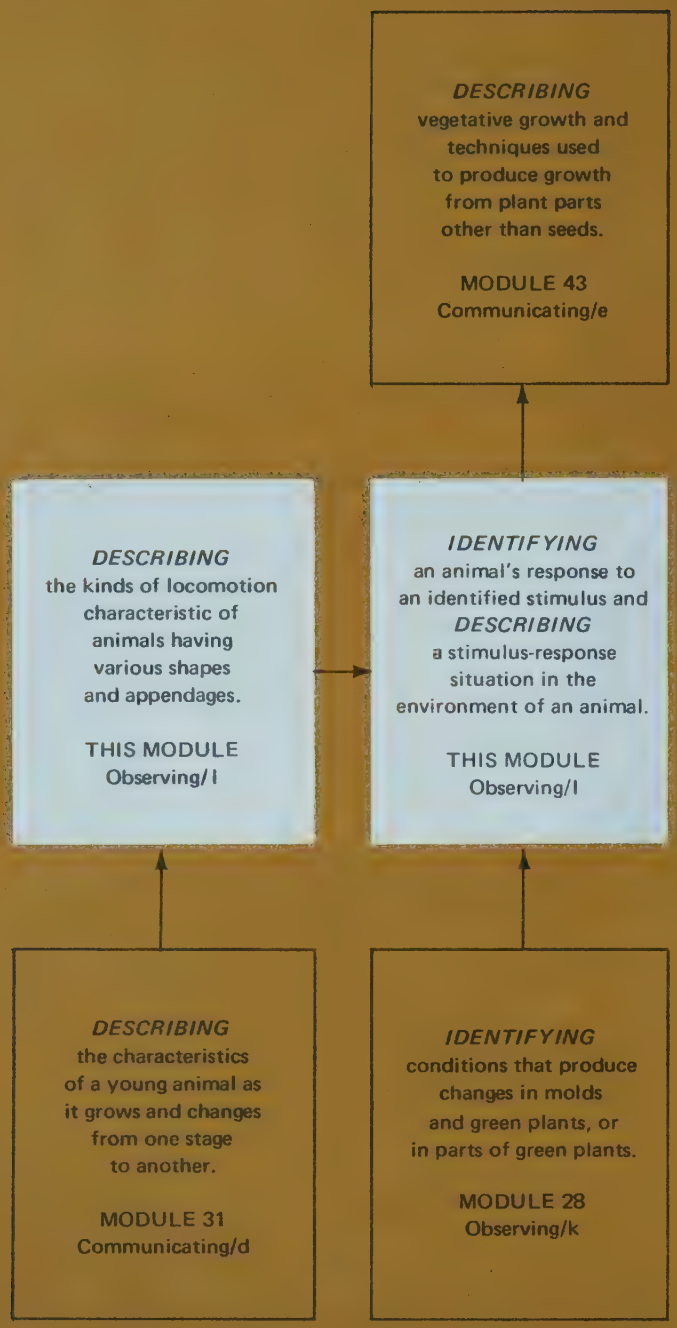
SEQUENCE


DESCRIBING
vegetative growth and techniques used to produce growth from plant parts other than seeds.
MODULE 43
Communicating/e
DESCRIBING
the kinds of locomotion characteristic of animals having various shapes and appendages.
THIS MODULE
Observing/I
IDENTIFYING
an animal's response to an identified stimulus and *DESCRIBING* a stimulus-response situation in the environment of an animal.
THIS MODULE
Observing/I
DESCRIBING
the characteristics of a young animal as it grows and changes from one stage to another.
MODULE 31
Communicating/d
IDENTIFYING
conditions that produce changes in molds and green plants, or in parts of green plants.
MODULE 28
Observing/k

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II**, is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173

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RATIONALE

One characteristic that distinguishes most animals from many other categories of organisms is their ability to move from place to place. Different animals move in different ways: Some animals crawl with their entire bodies (as the earthworm does), some walk with their legs, some swim or paddle through the water, and some fly through the air. Some animals can propel themselves through more than one medium with a different pattern of movement in each—a duck, for example, can walk, fly, and swim. Most children realize that self-propelled movement is a significant and distinguishing feature of animals.

Another distinguishing characteristic of animals is the way in which they respond to stimuli. All living things respond to changes in their environments, but animals usually respond to stimuli in a way that is more striking, more rapid, and more complex than that of other kinds of organisms, such as plants.

During this module, children observe how several animals typically move and respond to various stimuli. As they investigate animals' responses to stimuli, the children begin to learn about animal behavior. Thus, these activities prepare the children for future modules dealing with the behavior of living things.

Whenever possible, take the children outside so that they can identify naturally occurring stimulus-response situations of animals in their environments. Also, encourage the children to describe stimulus-response situations of animals that they have observed when walking in the woods, along a country road, on the way to school, or in a park. A show-and-tell period might be devoted exclusively to animal behavior.

Vocabulary

stimulus (plural stimuli)
response
locomotion

Advance Preparation

For *Activities 1* and *2*, you will need an aquarium in which to maintain about 10-15 goldfish. If your room doesn't already have an aquarium, arrange to obtain one. The presence of the aquarium in the room will allow the children to continue to observe the movement and responses of the goldfish even when *Activities 1* and *2* are not in process. You may wish to consult a book on the management of an aquarium. You should be able to find such a book in a library or pet store.

The fish's response to the food stimulus in *Activity 1* will be greater, if they are not fed for 2 or 3 days prior to the activity.

In addition to preparing water for the aquarium, you will need to prepare about 20 liters of water for *Activities 1* and *2*. For this purpose, set tap water aside in containers for at least 24 hours before the water is to be used in the activities.

INSTRUCTIONAL PROCEDURE

Introduction

Arrange for someone to make an unusual sound at the back or side of the room. After the children have responded to the sound by looking, jumping, or asking about it, ask them why they turned their attention in that particular direction. While the children are discussing the sound, flash a light toward the ceiling; you may wish to use a flashlight or a projector. Then ask the children why they looked toward the ceiling. Next spray a bit of perfume about the room, and ask, "Why are you wrinkling up your noses?"

Tell the children that you have a name for the sound they heard, the light they saw, and the odor they smelled—each one is a *stimulus.* Explain that a stimulus is anything that causes a living thing to react—that is, to change its actions—in some way. Then ask the children if they can think of a name for the action by which a living thing responds to a stimulus. The children may suggest the word *response;* if not, you should. Ask the children whether they can think of some other kinds of stimulus-response situations.

Ask questions such as the following only if necessary to get the discussion started.

If you have a puppy, what does he do when he sees you coming home from school?

What is the stimulus?

What is the response?

What does a baby do when it sees its mother?

Have you ever tried to walk on a wet, smooth floor? How is it different from walking on a concrete sidewalk?

Why is ice or a wet, slippery floor difficult to walk on?

How are your movements in response to the stimulus of the slippery floor different from your responses on a dry floor?

Materials

Flashlight, 1 (*Module 36*), or slide projector
Spray bottle of perfume, 1
(Note: Another strongly scented substance, such as room deodorizer will also work well.)

Activity 1

Give each group of four or five children a 2-liter, clear plastic container with a goldfish or a guppy in it. Ask the children to describe, in their own words, the movement of the fish. Then ask questions such as the following about specific aspects of a fish's movement.

What parts of its body does the fish use to move itself?

Does the fish's body stay straight when it moves or does it curve?

What does the tail do? How are the other fins used?

After this discussion, the children should understand that fish move by curving their bodies and wriggling their tails, and that the fins are important for balancing and steering.

Have the children count the number of times the tail of the fish moves during a 30-second interval; signal them when to start and stop. Although the numbers that the groups report will vary, they will all be surprisingly large. Now, for the same period of time, have the children count only the times the fish moves its tail but does not change its location—that is, does not go forward, backward, or sideways. This count will be surprisingly small, and it should help emphasize the importance of the tail in the fish's movement.

Ask the children how they can find out whether the fish will respond to stimuli. On the chalkboard, list the following stimuli: a tap on the side of the container, a marble dropped into the water, a paper clip on a string lowered into the water, a bright light flashed on the fish, and food sprinkled on top of the water. Ask the children to test the fish's response to each of these stimuli. If any children suggest that the fish may be hurt by some of these stimuli, tell them that none of these stimuli will harm the fish.

Before the children begin the investigation, discuss the procedures with them. Warn the children not to touch the fish in any way, either with their hands or with any of the objects involved in the investigation; the children should not put their hands in the water. Tell the children to try to drop the marble at least 5 centimeters away from the fish's head; since the fish is moving, these distances can only be estimated roughly. After observing the fish's response to the marble, have them remove it by using the fishnet. For best results, the children should tap the side of the container nearest the fish. Also tell the children to sprinkle only one or two flakes of fish food on the water when they test the fish's response to the food stimulus.

Give each group the materials with which to provide the stimuli, and give each child a copy of the chart *How Fish Respond to Stimuli* (see Figure 1). Suggest that the children fill in the chart with sentences or pictures, or with sentences composed of both words and pictures to describe the response of the fish.

Suggest that the food stimulus be given last, so that other stimuli will not interrupt the feeding. Some of the children may wonder how the fish's responses to other stimuli might be affected if the food stimulus were presented first. If so, arrange for one or more groups to repeat the series of stimuli the next day, this time giving the food stimulus first. Have these groups report their findings to the other children.

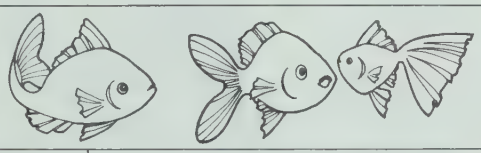
When the children have finished their investigations, discuss how the fish responded to each stimulus. If the children's observations differ about a response to a particular stimulus, try to resolve the differences by presenting the stimulus again. Ask the children which stimulus caused the most fish to respond, and which stimulus caused the fewest to respond. Then ask the children whether they can be certain that all fish would respond in the same way. Remind them that they have observed only one fish. Ask the children why it might be best to observe the responses of several different fish, or to observe the response of the same fish on several different occasions. The children should understand the importance of making as many observations as possible, since the responses of different fish may vary, and since the same fish may respond differently at different times.

At the conclusion of this activity, use a small fishnet to return each of the fish to the aquarium. Encourage the children to observe the fish frequently.

Materials

Containers, 6, 2-liter, clear plastic (*Module 36*)
Tap water, about 10 liters
(Note: Before using the water, let it stand in a container for at least 24 hours.)
Goldfish or guppy, 1 for each group
(Note: During this module, maintain the fish in an aquarium.)
Fishnet, 1 (*Module 36*)
Clock or watch with second hand, 1
Marbles, 1 for each group (*Module 57*)
Paperclips, 1 for each group
String, 1 ball (*Module 35*)
Flashlight, 1 (*Module 36*)
Fish food, 1 small container
How Fish Respond to Stimuli, 1 spirit master, Figure 1 (*Module 36*)
Pencils, 1 for each child

How Fish Respond to Stimuli



STIMULUS	RESPONSE
A tap on the side of the container	
A marble dropped into the water	
A paper clip on a string lowered into the water	
A bright light flashed into the water	
Food sprinkled on top of the water	

FIGURE 1

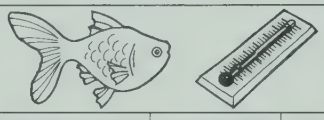
Activity 2

Begin this activity by asking the children what they think fish do when the water they are swimming in begins to cool. After the children have mentioned their ideas, suggest that they try to find out whether the temperature of the water is a stimulus for the fish.

Divide the children into groups of five or six, and give each group a 2-liter container holding water and three or four fish, and have the children observe how the fish swim. The children should observe that the fish swim about randomly in the container. Give each group a thermometer, and ask a child to measure the temperature of the water both near the surface and at the bottom of the container. Have each group record this temperature; it should be about room temperature. Have the children record their data for this activity on a copy of *How Fish Respond to Temperature* (see Figure 2).

Suggest to the children that they find out what fish do as the water gets cooler. Each group might set its container of fish in a bucket of ice packed around the container to a height of about 5 centimeters. While the children are doing this, set up an additional 2-liter container with fish and water, but leave this container at room temperature to serve as a control.

How Fish Respond to Temperature



	Temperature of water at bottom of container	Temperature of water at the surface	Response of fish (how and where fish swim)
Container at room temperature			
Container placed in ice 5 minutes			
Container placed in ice 10 minutes			

FIGURE 2

After about 5 minutes, ask the children to observe where the fish are swimming. Have a child again measure the temperature of the water at the bottom of the container and near the surface of the water and record these readings. Caution the children not to stir the water when they make their measurements. After another 5 minutes, again ask the children to note the position of the fish and the temperature of the water at both levels. The fish will probably swim closer and closer to the surface of the water as it cools from the bottom. Have the children compare the behavior of the fish in the cooled water with that of the fish in the control container.

In a follow-up discussion, ask the children how the fish responded to the cold temperature. The children should answer that the fish swam to the surface of the container, away from the cold water at the bottom. As a way of reviewing the meanings of "stimulus" and "response," ask the children to identify the stimulus and response in the situation they just investigated. The children should be able to point out that the cold temperature was the stimulus, and that the fish's response to the stimulus was to swim away from the cold.

The children may suggest putting ice cubes into the water in the container with the fish in it. You may want to let them try it. They will probably find that the fish do not go to the bottom of the container as the children might expect. If they measure the temperature of the water at the top and bottom of the container they will find that the temperature difference is not as great as it was when the container was placed in a bucket of crushed ice.

Allow the containers to return to room temperature before returning the fish to their aquarium.

Materials

Containers, 6, 2-liter, clear plastic (*Module 36*)
Tap water, about 10 liters
(Note: Before using the water, let it stand in a container at least 24 hours.)
Fishnet, 1 (*Module 36*)
Goldfish, 3-4 for each group
(Note: During this module, maintain the goldfish in an aquarium.)
Thermometers, 6, $^{-}20^{\circ}$ to 110° Celsius (*Module 41*)
How Fish Respond to Temperature, 1 spirit master, Figure 2 (*Module 36*)
Pencils, 1 for each child
Ice buckets, 1 for each group
(Note: Dishpans or other similar waterproof containers of about 4-liter capacity will work well.)
Crushed ice or ice cubes, amount sufficient to surround five 2-liter containers to a depth of 5 cm

Activity 3

Ask three volunteers to push hard against one wall of the room or against an immovable piece of furniture. Ask the other children to pay close attention to the feet of the children pushing. Now ask the same three children to squat and do a leap-frog jump and again ask the children to watch the "jumpers" feet closely and to tell what was the same about the jumping and the pushing. If no one mentions "feet pushing," ask the children who pushed and jumped what they noticed particularly about their feet. Ask them whether they were pushing harder with their feet when they were jumping or when they were pushing against the wall. If possible, repeat the jumping and pushing activities on soft ground or in sand on the playground, so that the children's footprints will indicate something about the push.

Ask the children whether they think that they push when they walk. Opinions may differ. As a demonstration, put two tables or desks close together, and ask a child to stand between them and to support his weight by placing his hands on the desks. (See Figure 3.) Tell the child first to move his feet in a walking motion without touching the floor, next to touch the floor lightly with his toes, and then finally to touch the floor as he would when walking; when the child's feet touch the floor, he will tend to move forward. Ask the children to describe what happened in each case. As a result of their observations, the children should realize that when they walk, their forward motion is caused by pushing against the floor with their feet.

FIGURE 3

Ask the children to bring to school shoes that are made for special purposes, such as golf, baseball, or football. Discuss the shoes' weight, cleats, or other features the children point out. Ask how each of these features might help or hinder the "push." Have a volunteer bring in roller skates and ask the child to put them on and try to walk forward normally. Ask the child if he is able to push back against the floor easily. Now ask him to try walking forward with his heels together and toes apart; walking should be easier this way. This experiment may help to establish the idea of the backward push in locomotion.

Have the children discuss how people walk, run, and swim. Suggest that they consider how such stimuli as a sudden and sharp noise, a cold breeze, and rough terrain affect people's movement.

Materials

Tables or desks, 2, approximately equal in height
Shoes made for special purposes, a variety such as golf, baseball, and football shoes brought by children from home
Roller skates, brought by children from home

Activity 4

Several activities are suggested. Each child should do at least one. Make it possible for small groups to do several if they wish. In each of the activities, where appropriate, have the children identify each stimulus and associated response as well as describe animal motion (see Figure 4).

1. Ask a child to bring in a pet hamster, gerbil, guinea pig, or rabbit, or supply one yourself. Put the animal on a rough surface such as burlap, and have the children observe the animal as it moves. Ask the children what the animal uses to move itself. Ask the children how they would expect the animal to move if it were placed on a smooth surface, such as a piece of glass or a polished floor. Now move the pet onto such a surface, and tell the children to observe the animal again. Ask them to note if the animal moves differently now than it did on the rough surface, and to try to explain any differences. The children probably will observe that the animal does not move as rapidly or easily on the smooth surface. The children should realize that this change in movement occurs because the animal's feet slip, and that it cannot push against the glass as well as it could against the rough surface.

Put a hamster or gerbil in a cage with a treadwheel and let the children observe the animal's feet as it tries to move forward. Now put the animal in a tray of smooth sand, and tell the children to examine the tracks it makes in the sand as it walks. Ask the children if they noticed any evidence that the animal pushes against the sand. They might mention the animal's tracks in the sand or the motion of the treadwheel; if not, point these out. The children might let the animal walk on their hands and arms so they can feel the backward push of its feet.

2. Put a toad, frog, or praying mantis in a tray of smooth sand, and ask the children to observe what happens to the sand as the animal walks or jumps. The children should notice that the animal pushes the sand back as it jumps. Include other animals in the discussion, always emphasizing the animals' push against a surface during locomotion, and the role of the animal's legs in this push. Have the children try jumping from a squatting position, with their heels together and toes apart. Ask them if they feel the push against the ground.

3. Ask the children how animals with no legs move and what such animals use to propel themselves. Put an earthworm on a piece of glass or clear plastic and tell the children to watch it try to move. Now put the worm on top of a wet paper towel, and urge the children to watch it move over the paper. The children will be able to see that the worm moves with a whole-body motion. To test this,

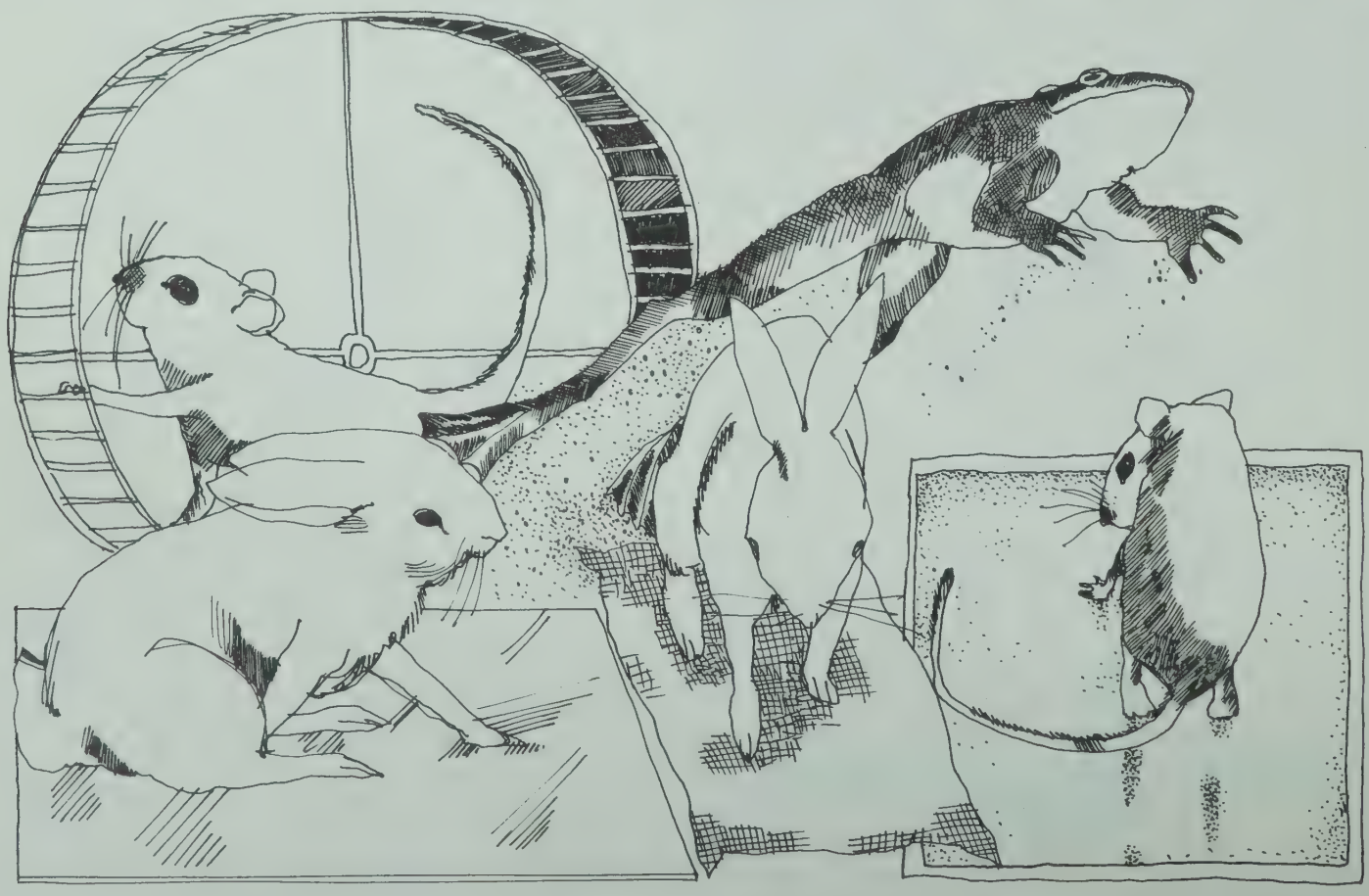


FIGURE 4

have volunteers touch the moving earthworm. They will feel waves of motion and the bristle-like hairs pushing against the surface.

4. Give the following optional demonstration to a small group of children at a time, so that they can all observe the animal's movements closely. Put a nonvenomous snake on the floor or table. Place a plastic sheet on the floor on each side of the snake. Start with the sheets about 20 centimeters apart. As the snake moves over the floor in a sideways motion, move the sheets closer together. The children will probably notice that when the sheets are only a little farther apart than the width of the snake, the snake can no longer move forward easily. A snake pushes with the curves of his body. He must curve his body to move forward, and he cannot do this between the closely spaced sheets.

Materials

Hamster, gerbil, guinea pig, or rabbit, 1, brought by child from home or supplied by you
Burlap, 1 piece for animal to walk on, or other rough surface
Glass, 1 sheet for animal to walk on, or other smooth surface such as a table top or a polished floor
Small animal cage with treadwheel, 1
Tray with sides, 1, or rectangular baking pan
Sand, enough to fill tray (*Module 36*)
Toad, frog, or praying mantis, 1, brought by child or supplied by you
Earthworm, 1, brought by child or supplied by you
Paper towels
Snake, non-venomous, 1 (optional)
Plastic sheets, 2, each about 60 X 20 X 0.5 cm (optional)

Generalizing Experiences

Do at least two of the following three activities.

Have a child bring in a pet hamster, gerbil, or guinea pig, or supply one yourself. On one of the plastic trays, place narrow strips of masking tape about 3 centimeters apart, like rungs of a ladder; paste or tape fine sandpaper on second plastic tray; and leave a third plastic tray smooth. Prop one end of each tray up to make an incline of 30 degrees, and ask which surface would be the easiest for the animal to walk down or up. Ask the children to give reasons for their suggestions. Let the animal walk up each one of the trays; a little food may be necessary to entice the animal up the tray. If the children are quiet the animal will be more likely to "cooperate." Ask the children to describe what they observe in each case, and to account for their observations. Try this with other animals—perhaps also with different degrees of incline.

Take a field trip around the school or to a nearby park. Ask the children to locate different kinds of animals, and to describe their type of locomotion. Encourage the children to describe responses to particular stimuli as they observe how the animals react to their environments. If pollution problems exist in these environments, help the children become aware of them.

Tell the children to pretend that they have caught a mouse, and want to keep it, but that they only have two containers, and neither one has a lid. Both containers are the same size and have fairly high sides, but one is made of glass and the other is made of wire screen. Tell the children to pretend that they can't turn the containers upside down. Ask the children in which container they would put the mouse to prevent it from escaping. The children should realize that the mouse would have more difficulty climbing up the smooth sides of the glass container.

Materials

Hamster, gerbil, or guinea pig, 1, brought by child from home or supplied by you
Trays, 3 (*Module 36*)
Masking tape, 1 roll
Fine sandpaper, 1 sheet (*Module 36*)
Books or boxes, several, for propping up one end of each plastic sheet

Grasshopper

Bee

Stimuli and Responses

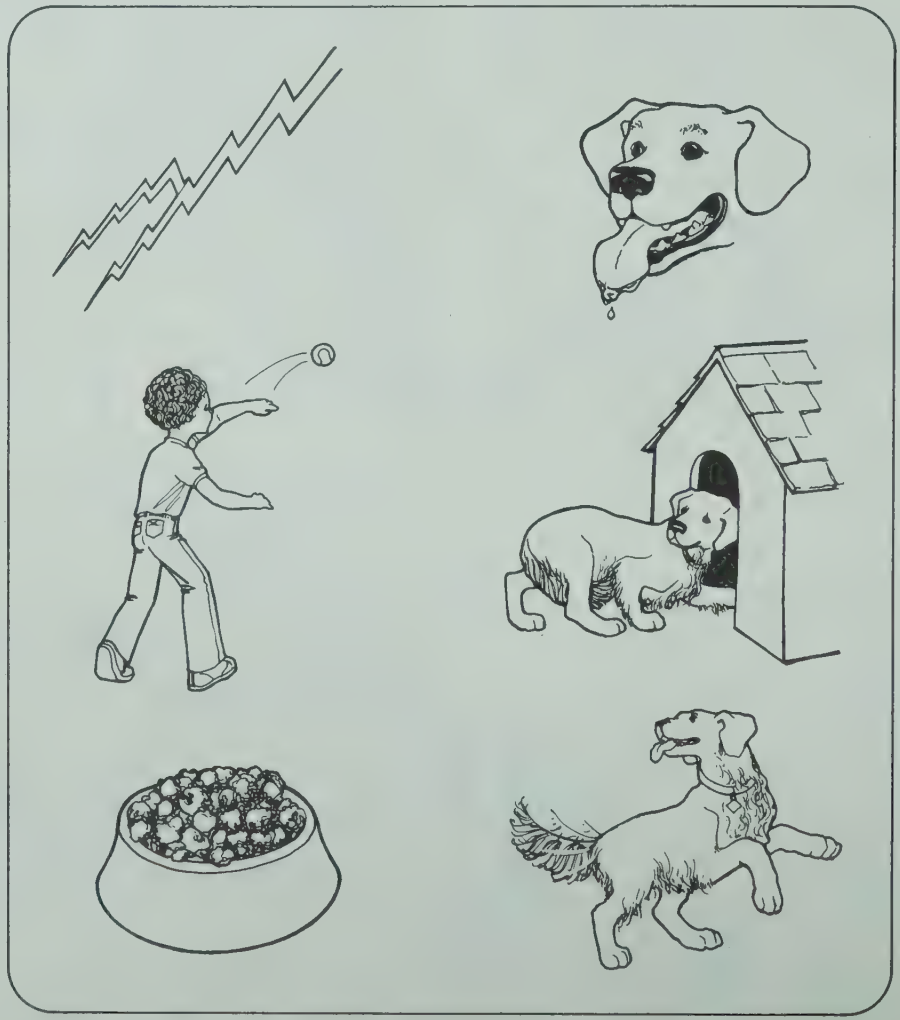


FIGURE 5

APPRAISAL

Give each group of two or three children a large, fresh-water snail in a container half filled with water. Large snails are preferable because they are easier for the children to see. If you can also obtain land snails, place them on a surface where the children can watch them.

Have the children watch the movement of the snail (or snails) to determine what parts of its body it uses in locomotion and how its body is propelled forward. Ask the children which other animals that they have observed moved most like the snail. (The earthworm.) Have the children watch closely for the little waves of motion that push the snail forward. Tell the children to note the fluid "road" that the land snail makes for itself.

Ask the children how they might learn more about the animal. If no one mentions it, suggest that the children provide various stimuli and observe the responses that result. Discuss with the children what stimuli might be provided. Any of those used to stimulate the fish in *Activities 1* and *2* would be appropriate; the children may also suggest other stimuli. Naturally, nothing should be done that would in any way harm the snail. Ask the children to make a chart similar to that used in *Activity 1* so they can record their observations. Follow the investigations with a discussion, and repeat any investigation about which there is disagreement.

Materials

Containers, 10, 250-ml, clear plastic (*Module 39*)
Fresh-water snails, several, large
(Note: You can obtain such snails at a tropical fish store and maintain them with the fish in the aquarium.)
Land snail, 1 (optional)
Writing paper, 1 sheet for each child
Pencil, 1 for each child

COMPETENCY MEASURE

TASK 1 (Objective 1): Show the child the picture card of a grasshopper (see Figure 5) and ask, **What kind of locomotion would you expect from this insect?** The child should indicate that the grasshopper hops or pushes with its legs.

TASK 2 (Objective 1): Say to the child, **Show me how a rabbit moves forward, and tell me what it does to move itself forward.** The child should demonstrate the characteristic "push" and explain that the rabbit's legs push against the ground.

TASK 3 (Objective 2): Show the child the picture card of stimuli and responses. (See Figure 5.) Say, **Identify the animal's response to each of the three stimuli and draw a line with your finger connecting the two.** The child should identify a response for each stimulus and justify each identification. There are no "correct" answers; thus justification is important.

TASK 4 (Objective 3): Show the child a picture of a bee on a flower (see Figure 5). Say, **Tell me why you think the bee is on the flower and what you think it is doing there.** The child should say that the bee is attracted by the smell and/or bright color of the flower and that the bee is resting and/or getting food there. It is not necessary that the inferences be those that you might make. Accept any appropriate stimulus-response situation that the child describes.

Materials

Picture card, 1, of grasshopper (*Module 36*)
Picture card, 1, of stimuli and responses (*Module 36*)
Picture card, 1, of bee on a flower (*Module 36*)

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36 Observing/1

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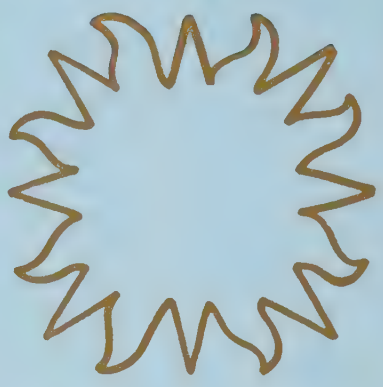

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SCIENCE...
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MODULE
37

Measuring /f

Forces

OBJECTIVES

At the end of this module the child should be able to

1. *IDENTIFY* balanced forces that act on a stationary object.
2. *STATE A RULE* that a force can cause a coil spring to stretch, and that the greater the force the greater the stretch.
3. *DEMONSTRATE* that two objects have the same or different weights by using a spring scale.
4. *DEMONSTRATE* by using a spring scale that a force is needed to move an object on a horizontal surface.

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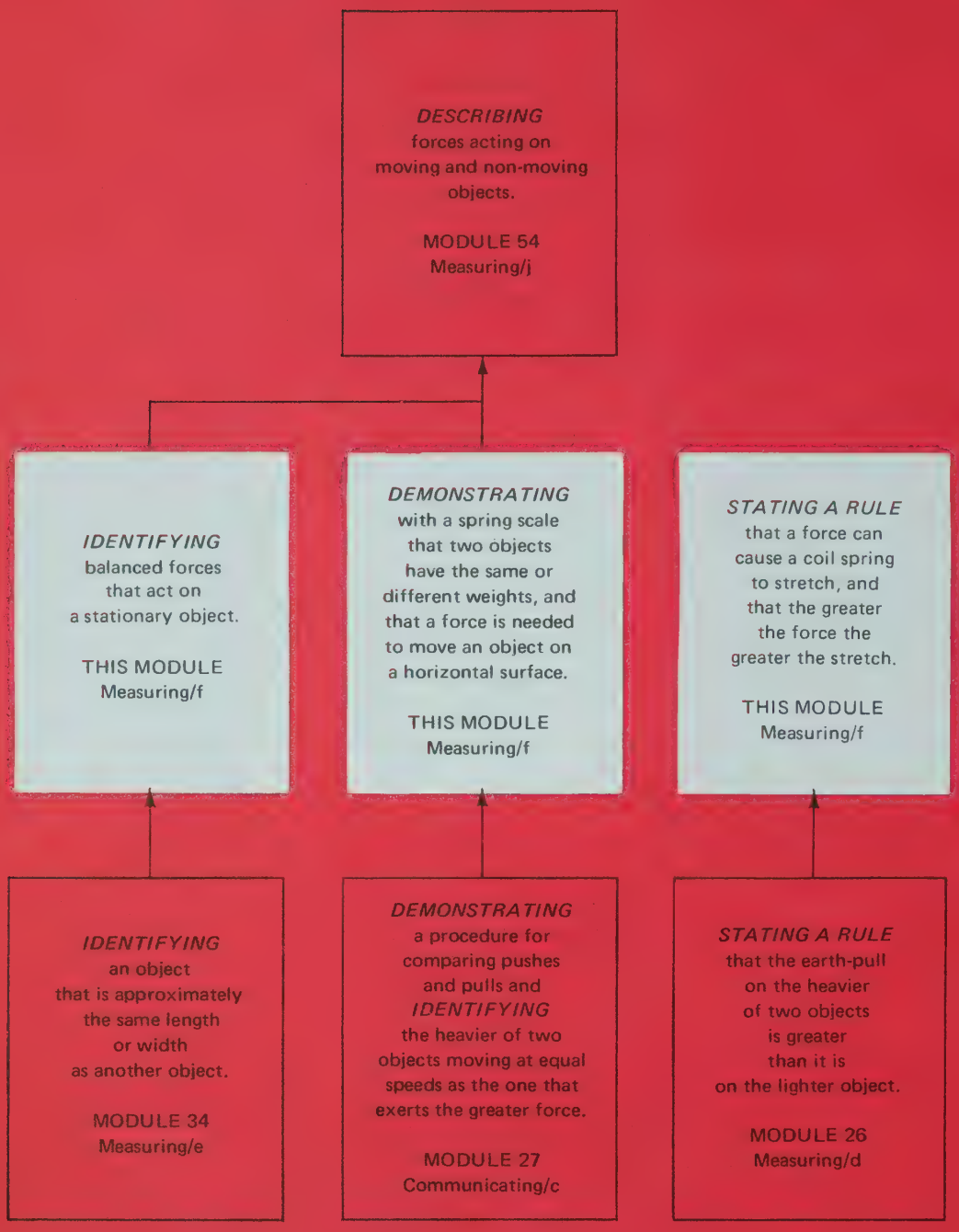
SEQUENCE


DESCRIBING
forces acting on moving and non-moving objects.
MODULE 54
Measuring/j
IDENTIFYING
balanced forces that act on a stationary object.
THIS MODULE
Measuring/f
DEMONSTRATING
with a spring scale that two objects have the same or different weights, and that a force is needed to move an object on a horizontal surface.
THIS MODULE
Measuring/f
STATING A RULE
that a force can cause a coil spring to stretch, and that the greater the force the greater the stretch.
THIS MODULE
Measuring/f
IDENTIFYING
an object that is approximately the same length or width as another object.
MODULE 34
Measuring/e
DEMONSTRATING
a procedure for comparing pushes and pulls and
IDENTIFYING
the heavier of two objects moving at equal speeds as the one that exerts the greater force.
MODULE 27
Communicating/c
STATING A RULE
that the earth-pull on the heavier of two objects is greater than it is on the lighter object.
MODULE 26
Measuring/d

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

Up to this point the child has used direct measurement to find length and volume. These are quantities that can be measured through observation. The child can see the height of another child and the volume of water in a container. However, in this module the child is asked to make a measurement of something he can feel, but not see—a force. A force applied to the end of a suspended coil spring causes the spring to elongate. Even though the force itself is not visible, the child can see its result—the stretching of the spring. The amount of stretching of the spring can be—and is—used as an indirect measure of the force.

You may need to review with the children the concept of force, particularly the idea of earth-pull introduced in *Using a Balance, Measuring d, Module 26.* There the children learned that they could use the equal-arm balance to determine whether or not two forces were equal. In this module, the spring scale is introduced as a device that provides another way to compare different forces. The distance a spring is stretched depends on the force applied to it, and therefore a spring can be used to measure forces.

Vocabulary

scale	weight
spring	earth-pull
force	

INSTRUCTIONAL PROCEDURE

Introduction

Give a child a spring and ask how many different ways it might be used. Ask if anyone knows what it is called. Have other children examine the spring and discover its uses. Ask the children to observe what happens when they pull on the spring.

Show the children two cylinders that are alike in size and color but different in weight. Ask one child to tell, only by looking at the cylinders, how they are alike. (In size, color, and shape.) Next, have another child pick the cylinders up and tell if they differ in any way. (One is heavier than the other.) Ask the children if they can think of a way to use the spring to tell something about the cylinders.

Show the children two spheres that are alike in size and color but different in weight. Have a child pick the spheres up and describe the feel of each. Again, ask the children if they can think of a way to use the spring to tell something about the spheres. Ask why one sphere is harder to lift than the other. If no one suggests it, explain that the earth-pull on one of the spheres is greater than it is on the other. Review the concept of earth-pull if necessary. Ask how earth-pull is related to the stretching of the spring.

Some children may want to use the term *gravity* instead of earth-pull. If they do, encourage them to say earth-pull instead.

Materials

Spring, 1, removed from a spring scale (*Module 37*)
Cylinders, 2, one wood and one aluminum, different in weight, alike in size and color (*Module 37*)
Spheres, 2, one light and one heavy, alike in size and color (*Module 37*)

Activity 1

Divide the class into groups of five or six. In addition to two cylinders and two spheres like those described in the *Introduction*, give each group a spring scale consisting of a support stand, burette clamp, spring apparatus, and a pan. Make sure that the scale is set up correctly. (See Figure 1.) Also make sure that the spring is of the right strength for weighing the cylinders and spheres. (See *Materials* for explanation.)

Ask the children to compare the results of placing each cylinder in the pan. Ask if the earth-pull on one is the same as on the other. Have the children take readings on the spring scale and draw conclusions about the difference in earth-pull on the two cylinders. If a group fails to state that one cylinder stretches the spring more than the other, suggest that this group compare the stretching caused by the two cylinders.

Repeat this activity with the two spheres, having the children make the same kind of comparisons that they made with the cylinders.

After all the groups have compared the stretching produced by their cylinders and spheres, ask the groups to share their observations and questions with each other. Although you may have to ask the first question, questions similar to these should develop:

Why does the spring stretch? (The cylinder is heavy, and it pulls down the spring.)

Can you make the spring stretch as far as the cylinder made it stretch? How? (Pull on the spring.)

When you pulled, did you exert a force on the spring? How do you know? (The spring stretched.)

What makes the spring stretch when the cylinder is in the pan? How can the cylinder exert a force on the spring? (The earth pulls on the cylinder and the cylinder pulls on the spring.)

What do you mean when you say, "The cylinder is heavy?" Why does one cylinder stretch the spring more than the other? (The earth-pull is greater on one cylinder than it is on the other.)

Throughout this activity, the children should answer questions in such a way that you are sure they are familiar with the following concepts:

1. Weight is a force.
2. The direction of the force called weight is down.
3. The measure of an object's weight is a measure of the earth-pull on the object.

Materials

Cylinders, 5 sets of 2, one wood and one aluminum, different in weight, alike in size and color (*Module 37*)

Spheres, 5 sets of 2, one light and one heavy, alike in size and color (*Module 37*)

Spring-scales, 5, each consisting of a support stand, burette clamp, pan, and spring apparatus with weaker spring (*Module 37*)

(Note: Two springs are supplied. Throughout this module, for each activity requiring the spring apparatus, select the spring that stretches moderately when the object being used is suspended from it.)

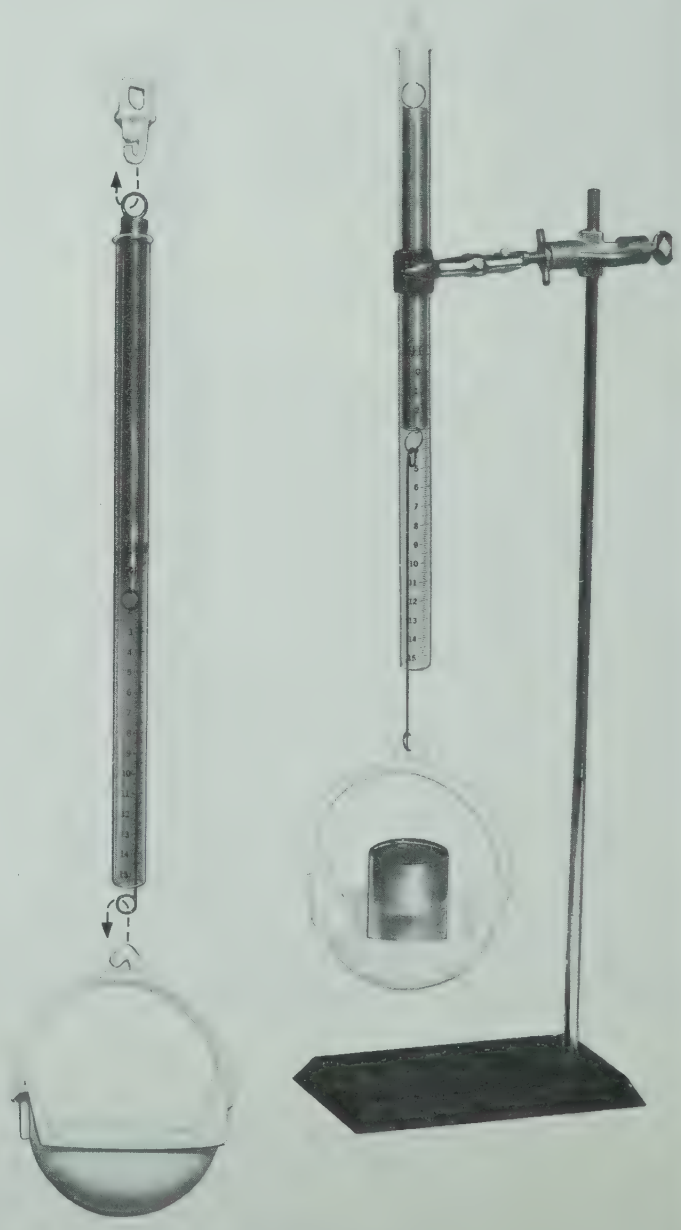

FIGURE 1

Activity 2

Have a child hold a ball in his hand, and ask the other children to tell you all they can about the forces on the ball. There should be statements such as these: "The earth pulls down on the ball, and the hand pushes up on the ball. These forces are in opposite directions." On the chalkboard, draw a hand holding a ball. (See Figure 2.) Tell the children that you are going to use one arrow to show the pull of the earth down on the ball and another to show the push of the hand up on the ball. (Note: The use of arrows here is just a convenient way to represent the earth-pull and hand-push.) Ask the children to tell you why the ball does not move. The children should develop the explanation that the upward force of the hand on the ball is the same as the downward force of the earth-pull on the ball, or the weight of the ball.

Have another child grasp a ball from above. Make another chalkboard drawing (see Figure 3) and discuss the forces on the ball. Ask the children to explain why the ball doesn't fall. (Because the force pulling up on the ball and the force pulling down on the ball are balanced.)

Next, release the ball and tell the children to watch it fall. Repeat this. Ask the children to explain why the ball fell. (When you let go of the ball, the upward force was gone; there was only a downward force.) You might ask if the force of the earth or earth-pull on the ball was any stronger when you released the ball than when you were holding it. (No. You removed the upward force on the ball and the ball fell.) This is a subtle point that needs to be discussed carefully. The earth-pull on the ball does not change when the ball is released; however, the ball falls because there is no longer any upward force on the ball exerted by the hand.

Some children may actually believe that the pull downward increased when you released the ball. To describe what happened, erase the upward-pointing arrow on the board. Explain that when the force upward was removed, there was no force to balance, or oppose, the force that tends to pull the ball to the earth; therefore, the ball fell. When the force on the ball was only in the downward direction, the ball moved down or fell.

Before going on to the next activity, emphasize again that the amount of the downward force acting on an object is called the object's weight. When we speak of an object's *weight*, we mean the amount of earth-pull on the object. Weight is a *force* acting downward.

Materials

Ball, 1, rubber (*Module 37*)

Activity 3

Divide the children into groups of five or six and give each group a different cylinder. Tell each group to find out how far in centimeters, the cylinder stretches their spring. Also give each group ten 2-centimeter cubes, and ask the children to determine how many cubes weigh (stretch the spring) as much as the cylinder. The children should state their results as "between three and four cubes," for example, or "between five and six cubes." Have each group record on the board the number of cubes needed to stretch the spring to the same length that the cylinder stretched it.

Ask questions such as the following: Which cylinder weighs the most? How can you tell from the results that you recorded? (The greatest number of cubes is needed to stretch the spring to the same length as the heaviest cylinder.) Why did the end of the spring move down and then stop after you put the cylinder or cubes in the pan? (The spring stretched until it was exerting an upward force that was equal to the downward force that the earth was exerting on the cylinder or cubes.)

Materials

Cylinders, 6, each a different weight; one each of aluminum, clear plastic, opaque plastic, and wood (*Module 37*)

Spring scales, 5, each consisting of a support stand, burette clamp, pan, and spring apparatus with weaker spring (*Module 37*)

Cubes, 50, 2-cm (*Module 37*)

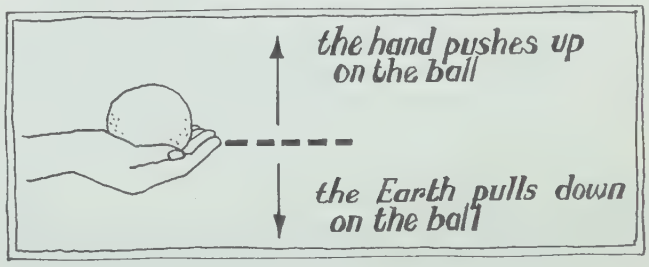

FIGURE 2

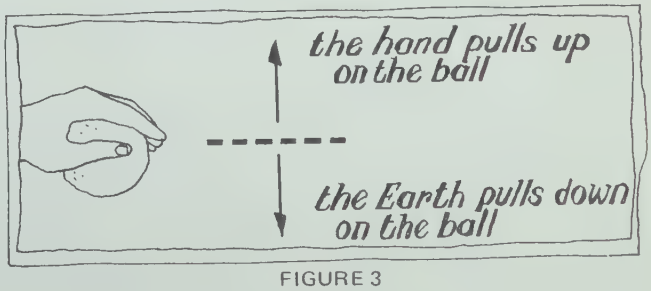

FIGURE 3

Activity 4

Show the children a cardboard or wooden box. (See *Materials* for description.) Tell a child to hold the box a short distance above a table or above the floor. Ask what forces are acting on it. (Earth-pull acting to pull the box downward; the child is pushing or pulling up on the box to hold it in the air.) Now have the child set the box down. Ask questions such as the following: Can the box be moved without lifting it? (Yes.) How? (By pushing it or pulling it.) Do you think it will take more force to pull it sideways than to lift it? Invite one or two children to pull the box a short distance, and then have them lift it.

Attach the spring apparatus to the one end of the box with a short piece of string. (See Figure 4.) Ask two other children to use the scale to find out what force is required to move the box steadily sideways. The length of the spring will probably change as the box is being pulled. Suggest that the children note the longest stretch while the box is moving. Let other pairs of children try this to see if they get the same result. Ask the class which kind of movement, pulling or lifting, takes more force. Use the spring scale to measure the force necessary to lift the box. Ask how the box can be moved more easily. (By attaching wheels, or by putting it on something that will roll easily.) Have on hand several dowels, short rods, or short lengths of pipe. Have different children measure and record on the chalkboard the amounts of stretch that register on the scale when they move the box on the rods.

You can make this activity open-ended by having children who are interested add varying amounts of load to the box and then measure the forces needed to move it under different conditions.

Materials

Box, 1, lightweight, cardboard or wood
(Note: The weight, not the size, of the box is important. The box should be light enough so that pulling it slowly across the floor or across a table will not stretch the attached spring more than 20 centimeters, even when the box has some objects in it.)
String, 1 meter (*Module 35*)
Spring apparatus, 1, with weaker spring (*Module 37*)
Dowels, 4, wooden (*Module 37*), or rods or lengths of pipe

Generalizing Experience

Have the groups of children compare the weights of cylinders by using marbles, washers, or other uniform objects as units of weight in place of the cubes. The children can compare their results by writing them on the board. Next the children can compare the weights of different units. For example, the children may learn that one washer weighs the same as three marbles. This activity should also suggest the conversion of one unit into another. To illustrate, suppose that the children find that a cylinder weighs as much as five washers. From the example above, they know that one washer weighs as much as three marbles. Therefore, the cylinder weighs as much as fifteen marbles.

Interested children might try using rubber bands to construct their own individual "rubber band scales" that operate like the spring scales.

Materials

Cylinders, 6, each of different weight; one each of aluminum, clear plastic, opaque plastic, steel, and wood (*Module 37*)
Spring scales, 5, each consisting of a support stand, burette clamp, pan, and spring apparatus with weaker spring (*Module 37*)
Marbles, 50, all uniform in weight (*Module 37*), or other uniform objects
Washers, 50 (*Module 37*)
Rubber bands, 30

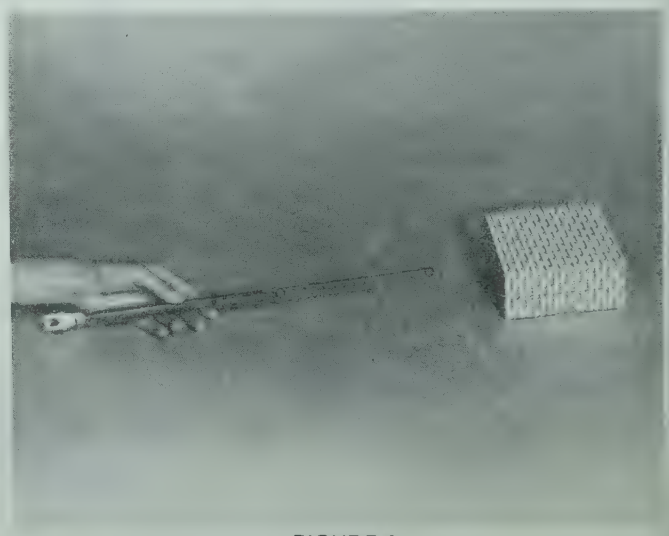

FIGURE 4

APPRAISAL

Give each group of five or six children a spring scale, ten 2-centimeter cubes, and a set of four larger cubes that differ in weight and size.

Ask each group to find answers to the following questions:

1. What will happen to the spring if the force downward is greater than the force upward?
2. Which object is heaviest?
3. Which object is lightest?
4. How many 2-centimeter cubes are required to stretch the spring as far as each of the larger cubes?

Now give each group a spring apparatus and two objects of different weights. Ask the children to use the spring apparatus to find out which object requires more force to be moved across the floor.

Materials

Spring scales, 5, each consisting of a support stand, burette clamp, pan, and spring apparatus with weaker spring (*Module 37*)
Cubes, 50, 2-cm, (*Module 37*)
Cubes, 5 sets of 4, differing in weight and size (*Module 37*)
Spring apparatus, 1, with appropriate spring (*Module 37*)
(Note: In advance, select the spring that has some "stretch" when each of the two objects is suspended from it.)
Objects, 5 sets of 2, one light and one heavy, each weighing no more than ten of the 2-cm cubes.

COMPETENCY MEASURE

TASK 1 (Objective 1): Hold up a book and ask, **What are the forces acting upon this book, and why is it not falling?** The child should say that the upward force of your hand on the book is the same as the downward force of the earth on the book. If the child's response is incomplete, elicit more information by saying, **Tell me more about the forces.** Ask for additional information only once.

TASK 2 (Objective 2): Give the child a spring scale, a large washer, and a small washer and ask **What would happen to the spring if the small washer were attached to it?** The child should state that the spring would stretch.

TASK 3 (Objective 2): Ask, **Would the spring stretch more or less if the large washer were attached to it?** The child should say that the spring would stretch more.

TASK 4 (Objective 3): Hand the child the two objects that are nearly equal in weight. Say, **Tell me which object is heavier.** If the child judges by lifting, say, **Show me how you can be sure.** The child should use the spring scale to find the heavier object. (Do not make an equal-arm balance available.)

TASK 5 (Objective 4): Put a chair on the floor beside the child and give the child a spring scale. Say, **Show me that a force is needed to slide the chair across the floor.** The child should attach the scale to the chair, pull the chair across the floor with the scale, and show you that the spring stretches.

Materials

Book, 1
Spring scale, 1, consisting of a support stand, burette clamp, pan, and spring apparatus with 2 springs (*Module 37*)
Washers, 2, one large (*Module 34*) and one small (*Module 37*)
Objects, 2, nearly equal in weight, but weighing no more than ten of the 2-cm cubes, small enough to fit in the pan of the spring scale
Chair, 1

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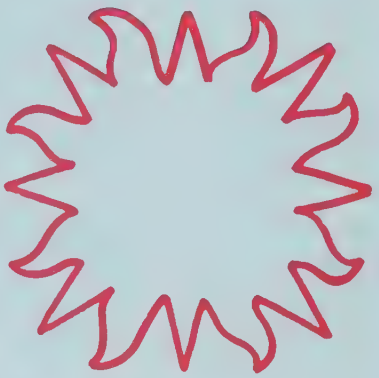
37 Measuring/f

SCIENCE...



A PROCESS APPROACH II

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SCIENCE... A PROCESS APPROACH II

MODULE
38

Predicting/a

Using Graphs

OBJECTIVES

At the end of this module the child should be able to

1. *CONSTRUCT* a bar graph, given a frequency distribution.
2. *DISTINGUISH* among quantities shown on a bar graph by using terms such as "greater than," "less than," "greatest," and "least."
3. *CONSTRUCT* predictions based on data presented in a bar graph.
4. *CONSTRUCT* a test of predictions based on data presented in a bar graph.

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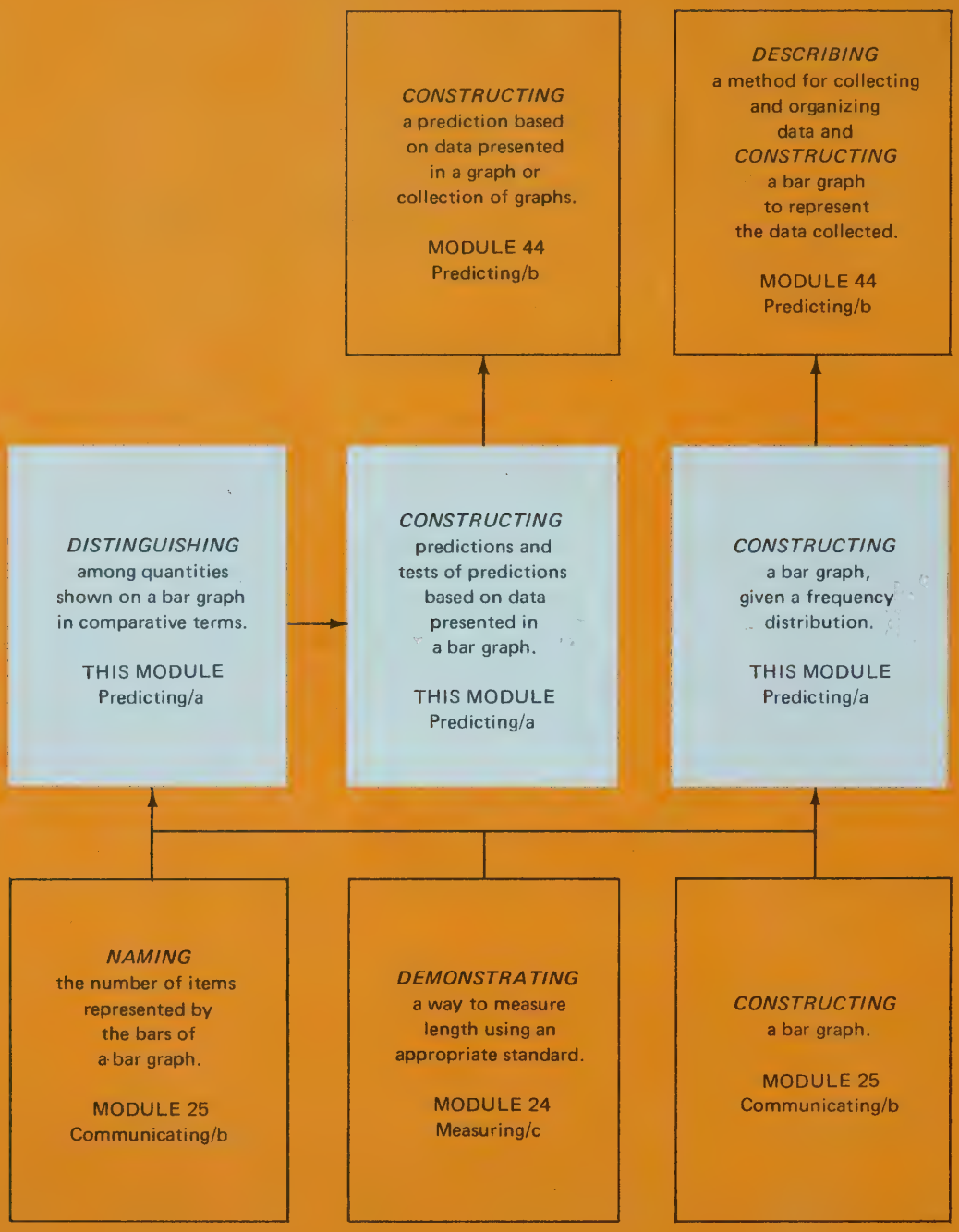
SEQUENCE


CONSTRUCTING a prediction based on data presented in a graph or collection of graphs.
MODULE 44 Predicting/b
DESCRIBING a method for collecting and organizing data and *CONSTRUCTING* a bar graph to represent the data collected.
MODULE 44 Predicting/b
DISTINGUISHING among quantities shown on a bar graph in comparative terms.
THIS MODULE Predicting/a
CONSTRUCTING predictions and tests of predictions based on data presented in a bar graph.
THIS MODULE Predicting/a
CONSTRUCTING a bar graph, given a frequency distribution.
THIS MODULE Predicting/a
NAMING the number of items represented by the bars of a bar graph.
MODULE 25 Communicating/b
DEMONSTRATING a way to measure length using an appropriate standard.
MODULE 24 Measuring/c
CONSTRUCTING a bar graph.
MODULE 25 Communicating/b

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II**, is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

As the children participate in the activities of this module, they will gain experience in constructing and interpreting bar graphs as a way of communicating information about sets of data. The graphing techniques in this module are an extension of those developed in *Introduction to Graphing, Communicating b, Module 25.* If necessary, review that module with the children before starting this one.

In the present module, the children's previous experience with reading scales on a vertical line (see Figure 1) is extended to reading scales on a horizontal line as well (see Figure 2). The children will read the scales on both lines to state the relationship represented by a given bar.

In an experiment in which one variable is changed and another variable is then measured to determine its dependence on the first, the data obtained can often be used to predict measurements not yet made. The first step is to discover the relationship between the two variables. Scientific work, however, often produces data in which relationships between two variables are not at all obvious. In such cases, constructing a graph, a pictorial representation of the data, can sometimes uncover a relationship. Graphing thus proves to be a useful tool early in the children's study of science, particularly as an aid to prediction.

Quantitative predictions from a graph can be made either between the recorded measurements (interpolation) or beyond the set of measurements (extrapolation). This module is concerned with extrapolation. In most cases, the data acquired and used exhibit simple number patterns that the children learn to recognize as they graph the data. The children can then make reasonable predictions based on those number patterns.

Data for graphing are suggested in each activity. Do not hesitate, however, to substitute data that might be of more interest or that the children themselves suggest. Having the children collect their own data whenever possible will spur their interest.

Vocabulary

predict	pattern
record (verb)	line graph (optional)
data	

INSTRUCTIONAL PROCEDURE

Introduction

A good way to begin this module is with a story. You may expand the story given here or change it entirely if you wish. As you tell this story, have the children supply the missing numbers according to some regular sequence. If they do not give the correct response immediately, you should offer it. The story is as follows:

Five children—Allen, Heather, Sue, John, and Dick—were walking to school one morning. Allen was very excited. "Do you know what? I went fishing on Saturday and I caught a great big fish."

"Oh," said Heather, "that's nothing. I caught two fish down by the mill."

Sue very determinedly said, "I caught . . . (three) fish when I went with my Uncle Jack."

John, not to be outdone by his friends, said, "Well, I did better than all of you. I caught . . . (four) fish."

Dick, who had been very quiet up to now, added with a twinkle in his eye, "I caught . . . (five) fish, but they were all made of paper. I was playing a game with my Dad in my own backyard."

Discuss with the children why they suggested the numbers they did. They might say, for example, "Well, the number should be one more," or, "That makes the numbers in order." Accept any reasonable ideas. Now introduce the word *prediction.*

Stress that a prediction is not merely a guess, that all predictions are based on data that are already available.

Activity 1

Give each child a copy of *Cubes,* the graph shown in Figure 1. Ask some of the children to describe it. If necessary, stack colored cubes on a table to remind the children that numerals are used to represent the number of cubes in each stack, and that colors are used to label the different stacks. On the graph, the colors refer to the colors of the cubes; the numerals refer to the number of cubes in each color stack.

When the children understand the information recorded in the graph, suggest that they take the graph home and test their mother, father, brother, or sister with it. When they hand it to the person they want to test, they might say, "This tells about something we did at school. What was it?" Some parents, brothers, or sisters will know right away how to answer the question; others may not. When the children return the next day, have them talk about what happened.

Cubes

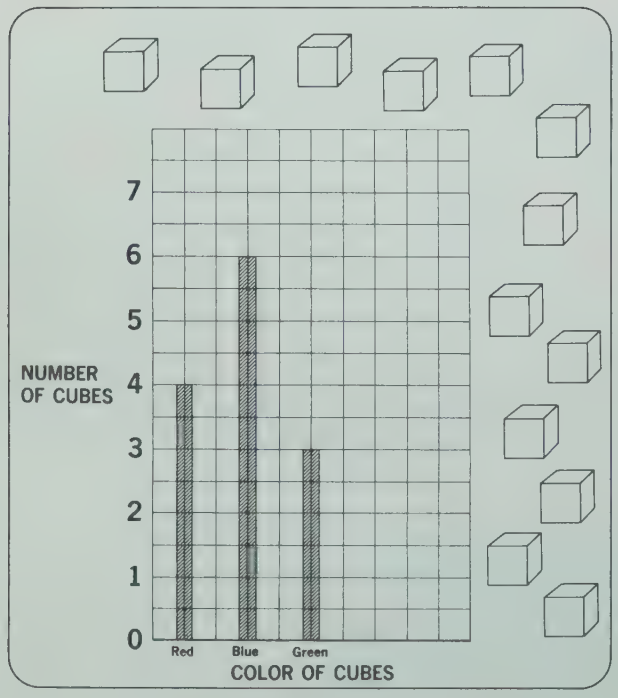

FIGURE 1

Remind the children again that a graph provides a way to remember something or to tell someone else about it—a way to record and communicate data. Tell the children that they will be making other graphs that they can use, if they wish, to tell someone at home about school. You might also wish to mention that they will learn how to use some graphs to make predictions.

Materials

Cubes, 1 spirit master, Figure 1 (*Module 38*)
Cubes, 13, 3-cm, 4 red, 3 green, and 6 blue (*Module 38*)

Activity 2

Before beginning this activity, calibrate a spring scale by preparing a masking-tape label marked so that the spring will move down one mark as each washer is added. Calibrate the scale up to 10 washers. If necessary, review with the children the use of the spring scale described in *Forces, Measuring f, Module 37.*

Let the children examine the spring scale you have set up and the washers to be weighed on it. Point out that there are no washers on the pan and that the pointer is at zero. Ask one or two of the children to tell you what will happen when one of the washers is placed on the pan. Because they have recently used the spring scale, the children will probably suggest that the spring will stretch and the pan will move down. Have one child put a washer on the pan and have another child read the new position of the pointer. Record the data on the chalkboard.

Ask a third child to place another washer on the pan and have a fourth child read the scale. If the scale has been calibrated with reasonable accuracy, the spring will extend 2 scale units. Repeat this procedure for three washers to obtain the reading of 3 scale units.

Ask two children to construct a graph of the data obtained. Have a flannel-board or chalkboard grid prepared for them in advance. In previous graphing experiences, the children extended each bar out to the adjacent verticals. Tell the children that now, after they have centered each bar on its vertical, they will be extending the bars only about one-quarter of the way toward the verticals on each side. You may want to demonstrate this on an overhead projector.

Let the two children construct the graph with little assistance from you. Confusion might arise, however, either here or during the later graphing activities, as to which number line should receive which label. In situations such as the present one, where a change in one variable (number of washers) results in a change in another variable (extension of spring), the variable causing the change is labeled along the horizontal number line. If necessary provide the children with a simple explanation of this convention.

As the two children are working at the large grid, the other children should be constructing individual graphs of the data using graph paper and pencils. The graphs should be similar to Figure 2, but do not expect perfection at this time. After the children have completed their graphs, you might wish to project an overhead transparency of Figure 2 so they can check their own graphs.

After the completion of suitable graphs, ask the children to predict how far the spring will stretch when four washers are in the pan. Then add the fourth washer, and have the children add a fourth bar to their graphs. Ask the children if they can see a pattern in the graph.

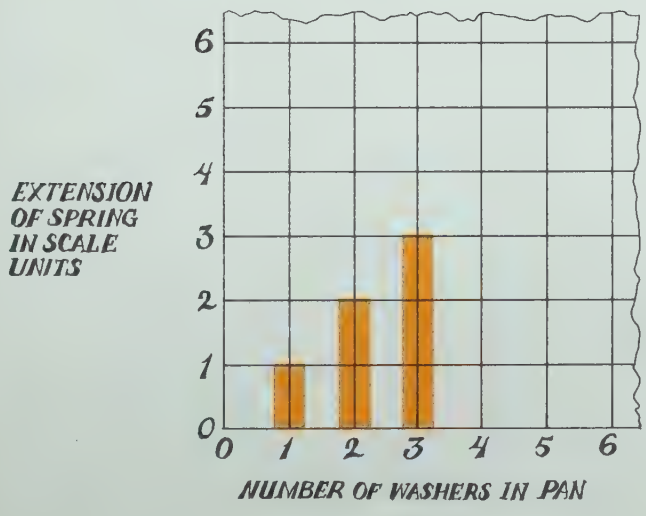

FIGURE 2

Ask for a prediction for five washers, and then for seven washers. At each point, the children should give a reason for their prediction and test their prediction before constructing the bar on their graphs.

If interest continues, let the children make further predictions and extend the graph. Ask the children if they believe they can continue to predict and test their predictions to extend the graph without end. If no one mentions it, point out that the spring will eventually stretch to a point beyond which it will not stretch any more, and that finally it will break. For this reason, it is impossible to predict and test the predictions without end. If you are willing to sacrifice a spring, the children can actually make the test. The spring probably will not break, but it will stretch beyond its elastic limit, after which the spring will not return to its former length.

You may wish to conclude the activity by summarizing with the children the steps that were involved in constructing and predicting from their graphs.

1. Collect data for two things that depend on each other in some way. (That is, when one thing is changed, something happens to the other.)
2. Construct a horizontal number line and a vertical number line that meet at zero. (You may wish to emphasize that in the graphs just constructed, the children used numbers along both the bottom and the left side of the graph.)
3. Label the two number lines.
4. Graph the data.
5. Look for a pattern in the data.
6. Considering the pattern, predict what will happen in further tests, but do not extend the graph too far (here, beyond the spring's elastic limit).
7. Test each prediction.

Materials

Spring scale, 1, consisting of a support stand, burette clamp, pan, and spring apparatus with the weaker spring (*Module 37*)
Masking tape, 1 roll, for calibrating spring scale
Marking pen, 1
Washers, 10 (*Module 37*)
Graph Paper, 1 spirit master (*Module 38*)
Pencils or crayons, 1 for each child
Transparency, 1, duplication of *Graph Paper* (*Module 38*)

Activity 3

In advance, calibrate one graduated cylinder for each group of children. Make a masking-tape label or scale for one graduated cylinder, and then make copies of it for the remaining cylinders.

To construct the initial scale, place one marble in a 50-milliliter graduated cylinder, then fill the cylinder with water to the 20-milliliter mark. Number the label so that the water level for one marble is at a number other than *1*—perhaps at *3*, as shown in Figure 3a. Being careful not to splash any water out, drop a second marble into the cylinder. Mark the new water level on the tape with a number that is one larger than the number marking the initial water level (see Figure 3b). Repeat this procedure until six marbles are in the graduated cylinder.

Divide the children into groups of four. Give each group five marbles and one of the specially calibrated cylinders containing one marble and water up to the 20-milliliter mark. Also give each child a sheet of graph paper. Ask the children to construct graphs showing the water-level change as each marble is added to their group's cylinder (see Figure 4). Caution the children to try to avoid splashing any water out of the cylinder as they add the marbles.

After each group has added three or four marbles to its cylinder, ask one child in each group to predict what the new water level will be when the next marble is added. This time, have all the children mark their group's prediction on their graphs before testing the prediction.

If interest continues and everyone's clothes are still dry, let the children make further predictions. Ask the children if they believe they could continue to predict new water levels and test their predictions without end. They will probably comment that if they put too many marbles in the cylinder, the water or the marbles will spill over. Emphasize that, because the equipment they are using has a limited capacity, it is impossible to predict and test the predictions without end.

Materials

Graduated cylinders, 8, 50-ml (*Module 38*)
Masking tape, 1 roll, for calibrating graduated cylinders
Marbles, 50 (*Module 37*)
Marking pen, 1
Graph Paper, 1 spirit master (*Module 38*)
Pencils, 1 for each child

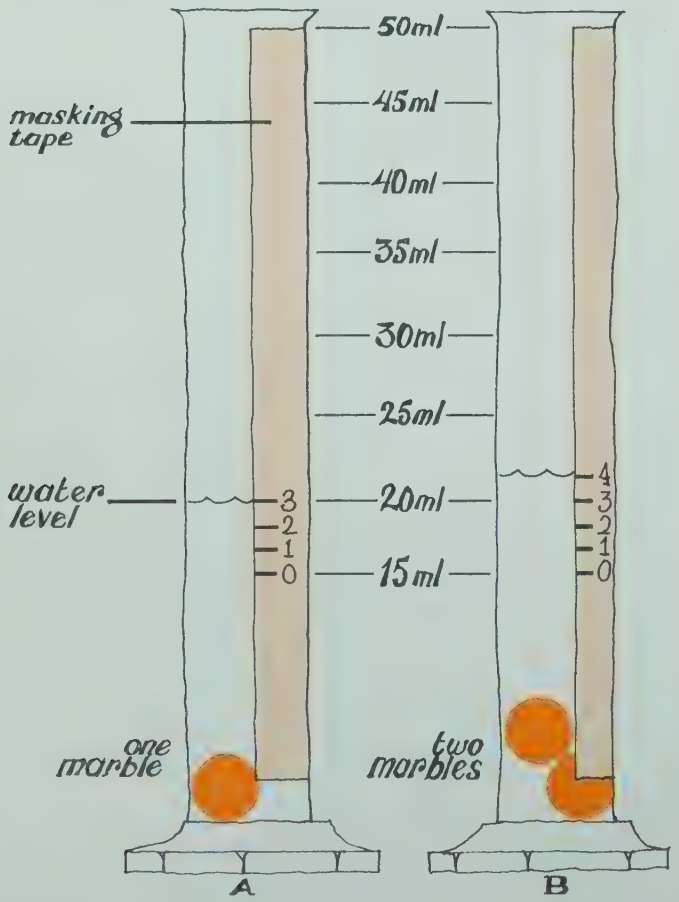

FIGURE 3

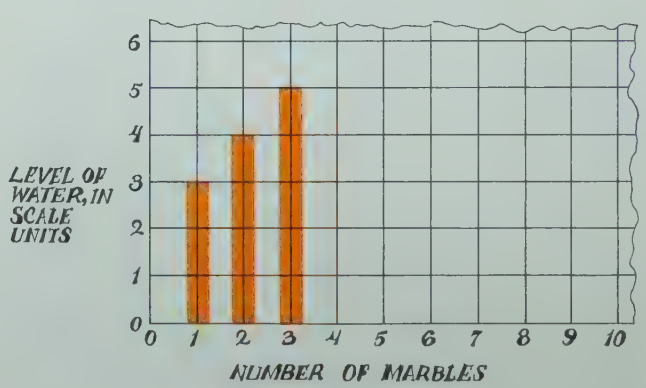

FIGURE 4

Activity 4

In this activity, a number of exercises provide the children with additional experience in the construction of graphs. For the most part, the exercises should be accomplished individually. However, you may want pairs of children to work together if this will benefit both children.

In each exercise, the children will construct a bar graph of data provided or collected. The children will choose appropriate scales and labels for the number lines in all the exercises except the first one. Not every child will need to complete all of the exercises. Some children might complete two sheets in a satisfactory manner and wish to do something else.

You may choose to substitute for the data suggested here other data that the children themselves have collected or that seem more relevant to their interests. Do not hesitate to make such substitutions.

1. Encourage the children to work as individuals or in pairs as they construct the graph entitled *Have a Seat*. After they have constructed the graphs, have the children show them to you for approval. The children's graphs should look like the completed graph shown in Figure 5.

2. After the children successfully complete *Have a Seat*, have them proceed with *Playing Ball*. Some of the children might initially try to label the vertical number line "Number of Balls" rather than "Number of Children." They will soon discover, however, that this labeling scheme will not work, given the size of the grid provided. The children should label the vertical number line "Number of Children" and the horizontal number line "Number of Balls." Compare their graphs with the completed graph shown in Figure 6.

With the assistance of the children, collect in advance the data for the next three graphs. Record the data on sheets of graph paper, or write the information on the chalkboard so that the children can copy it onto their graph paper as needed.

3. Pass a box containing a variety of small objects around the room. Have each child take a handful of items in "grab-bag" fashion, count the number of objects taken, and then return them to the box. Have the children

Have a Seat

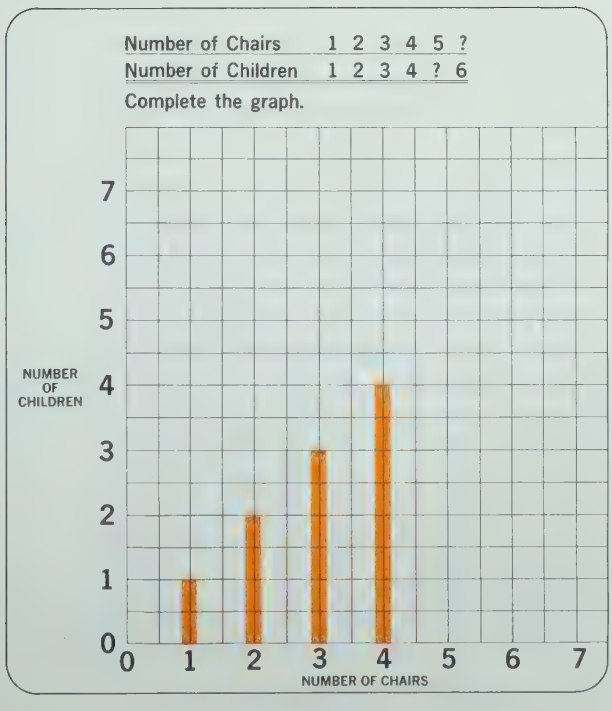

FIGURE 5

Playing Ball

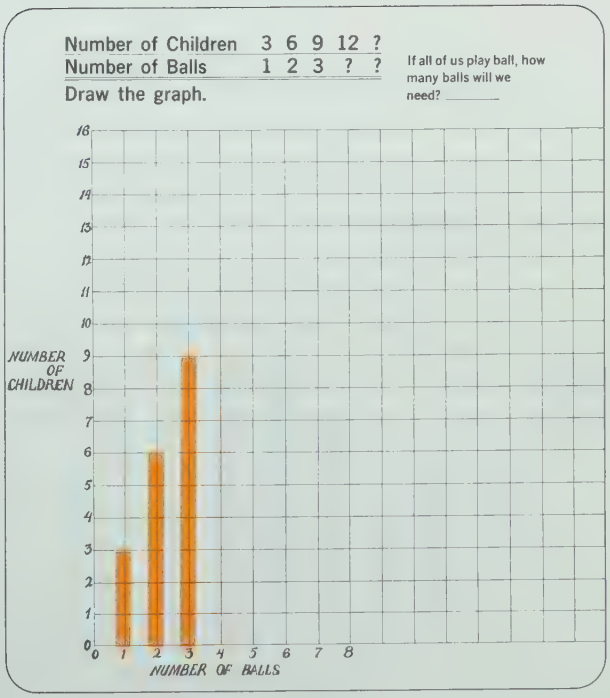
Number of Children 3 6 9 12 ?
Number of Balls 1 2 3 ? ?
Draw the graph.
If all of us play ball, how many balls will we need? _____
NUMBER OF CHILDREN
0 1 2 3 4 5 6 7 8
NUMBER OF BALLS

FIGURE 6

remember their numbers until everyone has "grabbed." Then ask each child to report his number of objects. The tally might look like this:

Number of objects withdrawn	1	2	3	4	5	6
Number of children withdrawing that number	///	//	////	𝍸	𝍸 //	/

In the above tally, three children withdrew one object, two withdrew two objects, and so on. Have the children tabulate the data for their class on their sheets of graph paper and construct individual graphs of the data. For comparison purposes, Figure 7 shows a graph of the data recorded in the tally above.

4. Attach to a wall or door frame about 2 meters of masking tape from the floor upward. With zero at the floor level, mark the tape in decimeters. Have the children work in pairs to measure their heights to the nearest decimeter. The tally of their heights might look something like this:

Height in decimeters	10	11	12	13	14	15	16
Number of children	0	//	𝍸 𝍸 //	𝍸 𝍸	////	/	0

Have the children tabulate the data for their class on their sheets of graph paper and construct individual graphs of the data. If the graph paper is not large enough for all the data to be recorded, the children might make a larger sheet by pasting or taping two sheets together.

For comparison purposes, Figure 8 shows a graph of the hypothetical data recorded in the tally above. You might want to show Figure 8 to the children, explain what it is, and ask why the graphs they have constructed are not exactly the same, even though the same type of data was collected.

Generally, the length from fingertip to fingertip of one's outstretched arms is approximately the same as one's height. If any child is sensitive about his or her height, you

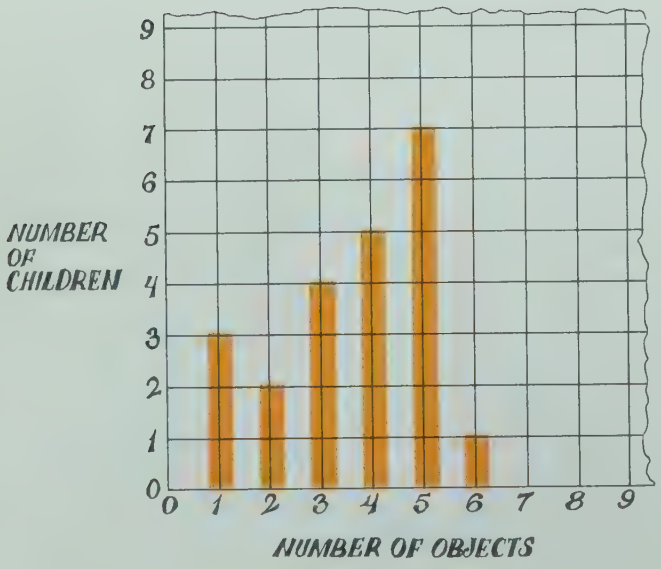

FIGURE 7

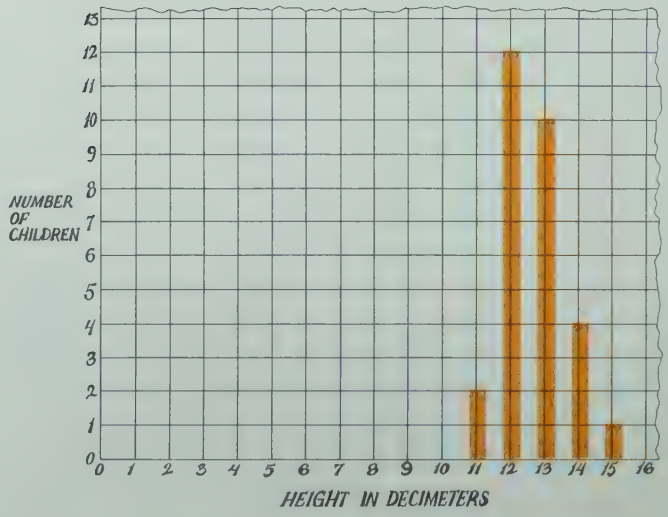

FIGURE 8

might prefer to have the children measure two-arm stretch instead. For additional interest, the children could collect both sets of data and compare the resultant graphs.

5. Ask each child in the class to write on a small piece of paper the number of children in his or her family. The results might be tallied as follows:

Number of children in the family	1	2	3	4	5	6	7	8
Number of families	𝍸 II	𝍸 III	𝍸 I	III	0	II	I	II

Have the children tabulate the data for their class on their sheets of graph paper and construct individual graphs of the data. For comparison purposes, Figure 9 shows a graph of the hypothetical data recorded in the tally above.

After the children have constructed their graphs, you might suggest a class discussion in which such questions as the following are answered by reading the graph: How many children does the (largest, smallest) family have? How many families have three children? Is the number of families with four children greater than the number of families with three children?

Materials

Crayons, 1 box for each child
Pencils, 1 for each child
Have a Seat, 1 spirit master (*Module 38*)
Playing Ball, 1 spirit master (*Module 38*)
Graph Paper, 1 spirit master (*Module 38*)
Box, 1
Small objects, about 10, to go in box
Masking tape, 1 roll
Marking pen, 1
Writing paper, 1 sheet for each child

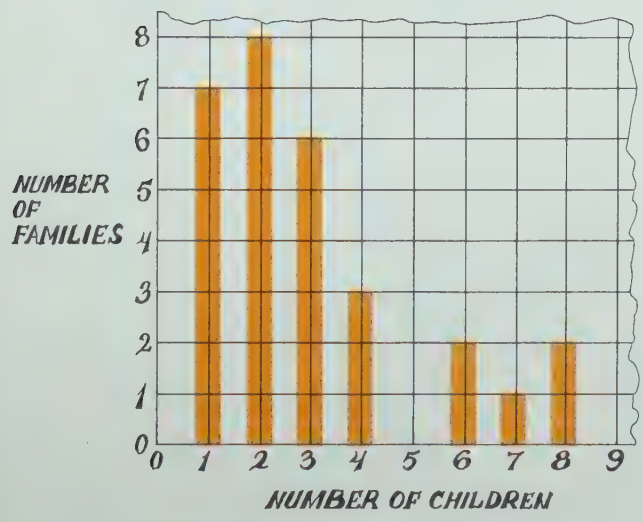

FIGURE 9

Generalizing Experiences

Give each child a copy of the bar graph *Bicycle Trip* (see Figure 10). Have the children imagine they are taking a bicycle trip. The bar graph records the distance the children would travel in the first 2 hours. Explain that the unit of distance being used is a kilometer, or 1000 meters.

Have the class discuss the distance/time relationship shown in the graph by answering the following question.

1. What would the bar look like that shows distance traveled in 3 hours? (Have the children add the third bar to their graphs.)
2. How long would it take to go 50 kilometers if you did not stop?
3. Would the bar for 6 hours go off the grid?

Because the bar graph (Figure 10) shows such a simple relationship, you may wish to use it to introduce line graphs. Suggest that the children mark a dot at the top midpoint of each of the three bars. Then have the children use a ruler to draw a line through these midpoints. If the children have placed the dots and drawn the line carefully, the line will extend from the lower left-hand corner of the grid upward and toward the right (see Figure 11). Do not insist, however, on perfect accuracy from the children trying this "excursion."

To help the children see that the line itself shows the same data as the bars, pursue a discussion such as the following: Each dot is above a number. What number is the first dot above? the second dot? Where would you place the dot for 4 hours? Mark that dot. Mark a dot at zero. What does this dot tell you?

Materials

Bicycle Trip, 1 spirit master, Figure 10 (*Module 38*)
Pencils, 1 for each child
Metric rulers, 1 for each child (optional) (*Module 34*)

Bicycle Trip

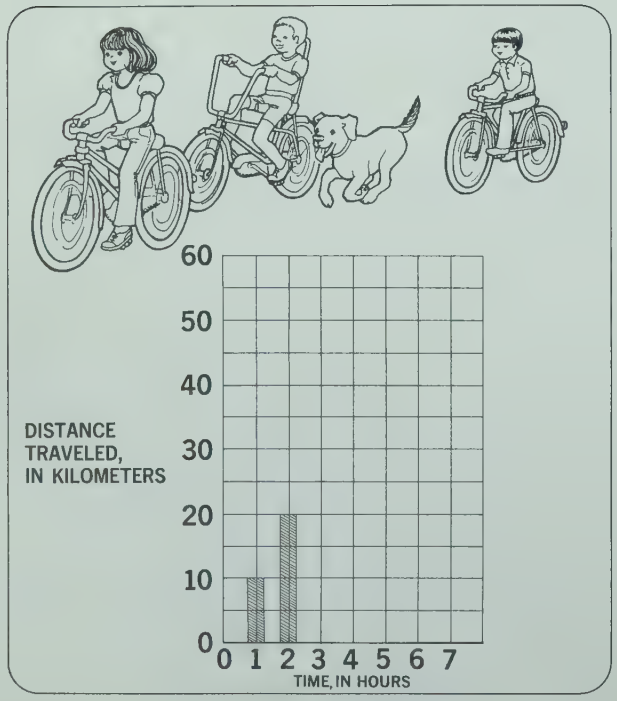

FIGURE 10

Bicycle Trip

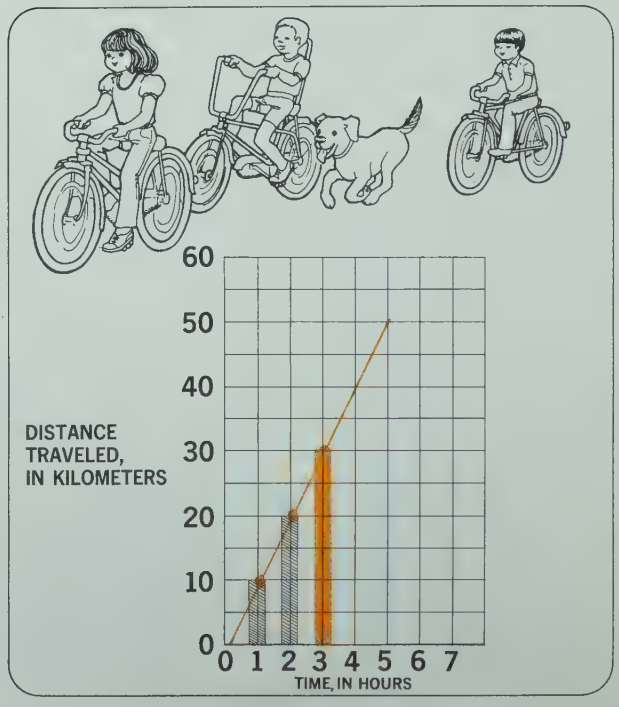

FIGURE 11

APPRAISAL

Give each child a sheet of graph paper. Provide tallied data for *Activity 4*, or some other set of data obtained about class members, to test the achievement of Objective 1.

After the children have demonstrated their ability to construct a graph, give each child a sheet of writing paper and a copy of *Marbles* (see Figure 12). Have the children write the numbers from 1 to 4 on the left side of the sheet of paper. Read the following questions slowly and ask the children to write their answers after the numbers.

1. How many marbles will weigh the same as 20 paper clips?
2. What does the taller bar represent?
3. How many paper clips do you predict will weigh the same as three marbles?
4. How many marbles do you predict will weigh the same as 40 paper clips?

Check answers with the children, discussing any questions they may have. When you feel the children understand the answers, ask them how they could test their predictions in questions 3 and 4.

Materials

Graph paper, 1 spirit master (*Module 38*)
Data, previously tallied, from *Activity 4*
Writing paper, 1 sheet for each child
Marbles, 1 spirit master, Figure 14 (*Module 38*)
Pencils, 1 for each child

Marbles

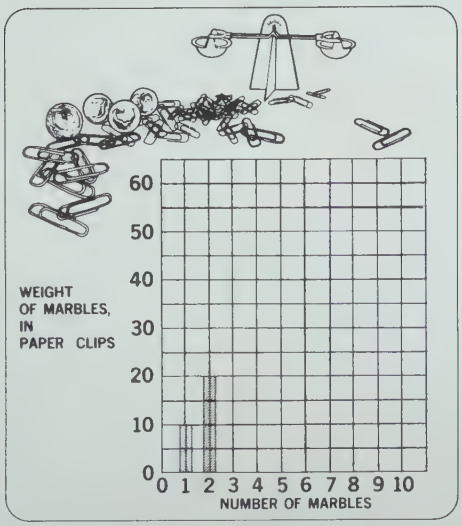

FIGURE 12

COMPETENCY MEASURE

TASK 1 (Objective 1): Give the child a sheet of graph paper, a pencil, and the following data.

Month	1	2	3	4
Number of children having birthdays	1	2	3	4

Say, Construct a bar graph showing the number of children having birthdays in each of the first four months of the year. The child's graph should contain no more than one error.

TASK 2 (Objective 2): Hold up the picture card showing the graph about birthdays. Read the number-line labels to the child, but do not explain the labels. Ask, In which month is there the greatest number of birthdays? The child should specify the fifth month, or May.

TASK 3 (Objective 3): Hold up the picture card showing the graph about plant growth. Read the number-line labels to the child, but do not explain the labels. Say, The graph shows the height of a plant at the end of each week for 3 weeks. How tall do you predict the plant will be at the end of the fourth week? The child should predict about 20 centimeters.

TASK 4 (Objective 4): While the child is still looking at the copy of *A Growing Plant*, say, Suppose we were growing this plant in our room, and today it is three weeks old. We measured it and found it to be 15 centimeters tall, as the graph shows. You predicted that in four weeks the plant would be __ __ __ centimeters tall. How could you test this prediction? The child's answer should include the idea that the plant should be measured after it has grown for another week.

Materials

Graph Paper, 1 spirit master (*Module 38*)
Pencils, 1 for each child
Birthdays, 1 picture card (*Module 38*)
A Growing Plant, 1 picture card (*Module 38*)

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MODULE

39

Measuring/g

Solids, Liquids, and Gases

OBJECTIVES

At the end of this module the child should be able to

1. *DEMONSTRATE* how to measure the volume of a liquid using metric units.
2. *NAME* the volume of a liquid in metric units.
3. *NAME* a substance as being a solid, a liquid, or a gas.
4. *DESCRIBE* the distinguishing characteristics of a solid, a liquid, and a gas.

XEROX

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AAAS

SEQUENCE

ORDERING the components of a mixture according to volume or weight.
MODULE 42
Classifying/e
CONSTRUCTING inferences about evaporation and condensation under various conditions.
MODULE 52
Inferring/d
DESCRIBING observations of the effect of a liquid on plant or animal material.
MODULE 58
Inferring/e
DEMONSTRATING the measurement of the volume of a liquid and *NAMING* the result in metric units.
THIS MODULE
Measuring/g
NAMING a substance as being a solid, liquid or gas and *DESCRIBING* its distinguishing characteristics.
THIS MODULE
Measuring/g
DEMONSTRATING a way to measure the volume of a container using a supplied standard of reference.
MODULE 23
Measuring/b
IDENTIFYING a substance as a solid or a liquid.
MODULE 17
Observing/g
CONSTRUCTING a simple classification scheme and *DEMONSTRATING* its use.
MODULE 32
Classifying/d

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0-663-30205-6

RATIONALE

In this module the child is introduced to metric units for measuring volume and to procedures for accurately measuring volumes. The child also becomes familiar with the principles by which matter is classified as solid, liquid, or gas.

Metric units used for the measurement of volume are of a convenient size and provide accurate measurements of small amounts. Furthermore, the units are closely related to linear measurements; for instance, one milliliter is one cubic centimeter.

Matter can be classified into three phases: solid, liquid, and gas. It is not necessary for the children to use the word phase. A substance is a *solid* if it has a definite volume and shape that can be seen, even though it may be necessary to look for these in small pieces of the substance, or particles. A substance is a *liquid* if it has a surface that can be seen and felt, but it lacks both a shape of its own and visible particles. A substance is a *gas* if it has no surface, no shape of its own, and no visible particles.

An example may make these distinctions clearer. A person can carry a solid on a flat surface, must use a container with sides to carry more than a few drops of liquid, and needs some kind of lid on the container to carry a gas. Liquids and gases are similar in that both take the shape of the container that holds them. On the other hand, a liquid has a top surface that can be seen and felt, whereas a gas fills the container evenly and cannot be felt at any point unless the gas moves.

The concept of the gaseous phase is one of the most difficult for children to grasp, mainly because most gases are colorless. Some children may be confused because gasoline, a liquid, is called "gas." You might explain that the word is shortened in the same way that Thomas becomes "Tom" and Nancy becomes "Nan."

The concept that the volume of a liquid remains constant as the liquid is transferred from one container to another, assuming that the temperature remains constant, is basic in the measurement of volume. Although this concept of constancy of volume is obvious to adults, it presents difficulties to some young children. These difficulties may be resolved by experience in measuring the volumes of liquids.

For some substances there can be no sharp distinction made between the solid and liquid phases; for example, solids like modeling clay and butter have no visible particles and are easily pressed into different shapes. If the children ask about these, tell them that in borderline cases they can classify substances as solids if they are more like solids than liquids, but as liquids if the reverse is true.

Vocabulary

liquid	volume
solid	liter
gas	milliliter
matter	graduated cylinder
substance	vial
particle	compressed

INSTRUCTIONAL PROCEDURE

Introduction

Divide the children into three groups. Give each group two stones, two balloons, and two containers, one of colored water and one of plain water. Have the children classify the *contents* of these objects in any way that they choose, and then discuss their classifications. Explain that the water, stones, and air can each be placed in a different category and that each of the categories has a specific name. The term *liquid* applies to the plain and colored water, the term *solid* applies to the stones, and the term *gas* applies to the air inside the balloons. Now have the children classify the objects according to this system if they did not use this system the first time. Have the groups suggest the distinguishing characteristics of a solid, a liquid, and a gas.

Materials

Containers, 6, 250-ml, clear plastic (*Module 39*)
Food coloring, 1 container (*Module 39*)
Stones, 6
Balloons, 6, of different colors (*Module 39*)
(Note: The balloons should be filled with air and closed with small rubber bands before being given to the children.)
Rubber bands, 6, small

Activity 1

Ask each child to put one of his wrists between his nostrils and his upper lip. Demonstrate what they should do. Now ask them to breathe out through their noses. After the children have done this several times, have the children talk about what they have observed. Questions such as the following may stimulate the discussion:

What did you feel?
What did you see on your wrist?
Did it make your wrist feel wet?
Could what you felt have been a liquid?
Could it have been a solid?
If it was neither a liquid nor a solid, what was it?
How can you be more certain?
Did you feel it moving?

As an alternate activity you might ask a child to breathe out onto a small mirror while other children observe what happens.

Materials

Mirror, 1, about 5 x 10 cm

Activity 2

Ask the children to describe a liquid. If the children do not suggest that liquids can be poured, tilt a partially filled container of water in front of them. The movement of the liquid should suggest pouring. Have one of the children pour the water into a container, then ask the children what they observe about the water. (The surface stays level and the liquid takes the shape of its container.)

Ask if a solid or gas can be poured. Have a child pour a container of sand into an empty container. Ask if the water and sand behave the same way or differently when poured. (The sand takes the shape of the container just as a liquid does. The surface of the sand is not flat like that of the water, but builds up in a mound. You can see pieces of sand, but you can't see pieces of water.) Have the children look at the sand through hand lenses so that they may more easily observe the sand particles.

Materials

Containers, 4, 250-ml, clear plastic (*Module 39*)
Sand, 1 liter (*Module 39*)
Hand lenses, 15 (*Module 31*)

Activity 3

Divide the children into groups of three or four and give each group a graduated cylinder, a funnel, and two containers, one containing some sand and a second containing about 25 milliliters of water. Have the children measure the volume of the sand and then of the water with the graduated cylinder. They may place the funnel in the top of the graduated cylinder when they are pouring sand or water into it. (See Figure 1.)

The children may wonder what the numerals on the graduated cylinder are for. You might tell them that the cylinder is marked in milliliters and that there is a numeral every 5 milliliters. If the cylinder is filled with water to the top mark it contains 50 milliliters of water. The small divisions on the scale are milliliters.

Have a child fill the cylinder with water to the 50-milliliter mark and pour the water into a 2-liter plastic container. Ask another child to do the same thing. Repeat this until twenty 50-milliliter portions of water have been poured into the container. Mention that there is 1 liter of water in the container. Ask the children how many milliliters there are in a liter ($20 \times 50 = 1000$). You might have the children do this problem as multiple addition. Point out the similar relationship of a milliliter to a liter and of a millimeter to a meter.

As the children use the graduated cylinders to measure the volume of the sand and of the water, they will encounter problems. Some problems will be obvious to the children. You will need to point out other problems such as the following.

1. If the graduated cylinder is held at an angle while the level of the substance is read, there is a chance for error in measurement. Ask a child to demonstrate this by tipping the graduated cylinder to show how the level changes. Ask how they can overcome this difficulty. (By placing the cylinder on a level surface before reading the volume.)

2. The children should be sure that their eyes are level with the top surface of the substance when they read the volume in the graduated cylinder. (See Figure 1.)

3. When sand is poured into the graduated cylinder the surface may not be flat. Have the children tap the cylinder until the surface is flat and level.

Materials

Graduated cylinders, 10, 50-ml (*Module 39*)
Containers, 20, 250-ml, clear plastic (*Module 39*)
Funnels, 10 (*Module 39*)
Sand, 1 liter (*Module 39*)
Containers, 6, 2-liter, clear plastic (*Module 36*)

Activity 4

Give each pair of children one vial and a container of water. Ask the children to hold their vials, open end down, and push them into the water. Have them describe what happens. Ask them why the water does not fill the vial. Someone may suggest that the water does go into the vials, even though he cannot see it. Ask the children how they can tell whether water actually goes into the vial. Float a small cork on the water. Have the children hold their vials, open end down, and push them down into the water, over the cork. The cork will be depressed deeper into the water, and very little water will enter the vial.

Someone may suggest putting a wad of paper in the bottom of the vial, immersing the vial upside down in the water, and then observing whether or not the paper inside the vial gets wet.

Let the children make the test however they choose. Ask them what they observe. Some may note that the vial exerts a force upward so that a push downward is necessary to hold it under water. Ask the children how they could make the water go into the vial. The children may suggest that all they have to do is turn the vial sideways in the water. Let them try this and describe what they observe. Ask if they saw bubbles rising from the vial and what this indicates. The children should recognize that the bubbles which appeared were the air, or gas, that was trapped inside the vial.

Materials

Vials, 15, 30-ml (*Module 39*)
Containers, 15, 250-ml, clear plastic (*Module 39*)
Corks, 15 (*Module 39*)

Activity 5

Have the children bring in pictures of things that are gases, liquids, and solids. Have the children take turns using the pictures they brought in to point out the distinctions between gases, liquids, and solids. At the end of the discussion review the distinctions as outlined in the *Rationale.*

Materials

Pictures of gases, liquids, and solids brought in by the children

FIGURE 1

Generalizing Experiences

Show the children a graduated cylinder and several marbles. Pour 25 millimeters of water into the cylinder, and have someone read the volume. Ask if anyone can suggest a way to find the volume of a marble by using the graduated cylinder and the water. If no one suggests it ask what will happen to the water level if a marble is dropped into the water. Let a child demonstrate that when a marble is put in the water the level rises. Ask how much the water level changed. Have someone read the new volume. Ask what the volume of the marble is. Discuss with the children the process of displacing water to measure the volume of a solid. Repeat the procedure with a stone to demonstrate that this method can be used to find the volume of an irregularly shaped solid.

Ask the children if they can think of a way to use the graduated cylinder and water to measure the volume of air they breathe out in one breath. They probably will not be able to think of a way, so you may have to demonstrate how this can be done. Fill a bottle with water and place a piece of paper over the mouth of the bottle. Invert the bottle into a container that is half full of water (see Figure 2). When the mouth of the bottle is below the surface of the water, slide the piece of paper away. Try not to let any air in the bottle. Divide the children into groups of five and have each child in turn blow through a straw, holding the end of the straw under the mouth of a bottle so that the child's breath is collected in the bottle. (See Figure 2.) With a wax pencil, mark the level of the water in the bottle. Remove the bottle from the container and with a graduated cylinder, measure how much water it takes to fill the bottle to the mark. This is the volume of the child's breath. (See Figure 3.) Inform the children that for health reasons they are to change the water and straws, and rinse the equipment after each use. The children will probably be interested to find that their breath volumes are not the same.

Materials

Graduated cylinders, 10, 50-ml (*Module 39*)
Marbles, 10 (*Module 37*)
Stones, 10
Bottles, 6, 1-liter
Containers, 6, 2-liter, clear plastic (*Module 36*)
Drinking straws, 30
China-marking pencils, 8

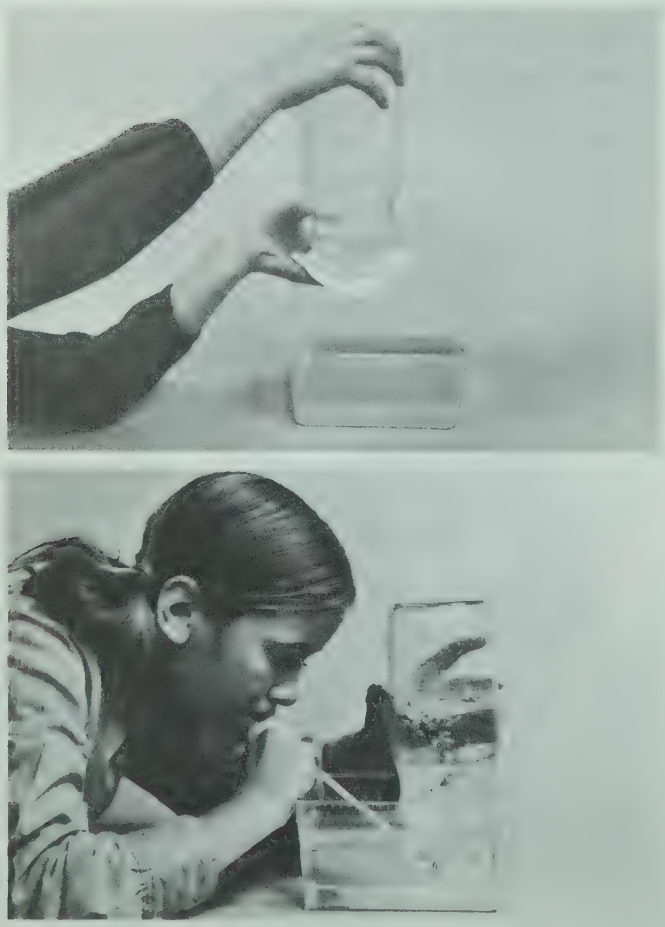

FIGURE 2

FIGURE 3

APPRAISAL

Divide the children into eight groups, and give each child a container. Half of the containers for each group should be 120-milliliter capacity and half 250-milliliter capacity. Give each group a graduated cylinder, a funnel, and a flask containing about 50 milliliters of punch for each child. Tell the children that they may drink the punch after it has been equally divided so that each child has an equal amount, or volume. Ask each group to tell you in metric units how much punch each child should get.

Put a clear plastic container half full of water in a place where all the children can see it. With tongs, drop a piece of Dry Ice into the water. Ask the children to describe what they see. Be sure that they use the terms solid, liquid, and gas in their descriptions.

Materials

Containers, 15, 120-ml (*Module 39*)
Containers, 16, 250-ml (*Module 39*)
Graduated cylinders, 8, 50-ml (*Module 39*)
Funnels, 8 (*Module 39*)
Flasks, 8, 250-ml (*Module 39*)
Punch, 50-ml for each child
Tongs, 1
Dry Ice, 1 piece

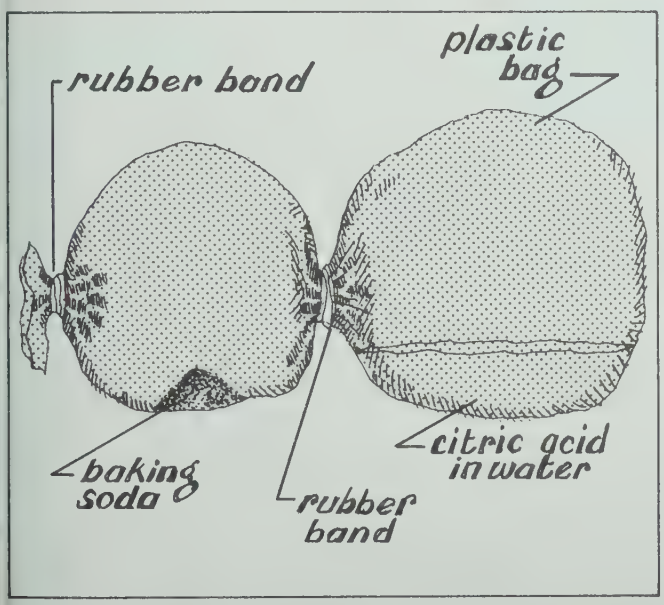

FIGURE 4

COMPETENCY MEASURE

Make the following advance preparation: Dissolve 12 to 15 grams of citric acid crystals in 50 milliliters of water and put the solution in a plastic sandwich bag. With a rubber band tightly seal off the bottom section of the bag. Then put 5 grams of baking soda in the open part of the bag, and tightly seal it with a second rubber band. (See Figure 4.) Save this set-up for Tasks 3 and 4.

For Tasks 1 and 2, give the child the following materials: a graduated cylinder, a container with approximately 100 milliliters of colored water, a funnel, and an empty container.

TASK 1 (Objective 1): Say to the child, Put 40 milliliters of this liquid (point to the container of colored water) into this empty container (point to container). The child should use the graduated cylinder and measure out the desired volume to within 5 milliliters.

TASK 2 (Objective 2): Pour the measured liquid from Task 1 back into the original container. Say, Measure the volume of the liquid in this container (point to container). Tell me its volume. The child should measure the volume to within 5 milliliters and report the measurement to you.

TASK 3 (Objectives 3, 4): Hand the child the plastic bag which you previously prepared. Ask, Can you see liquids, solids, or gases in this bag? How do you know? The child should say that there is a liquid in one part of the bag and that he or she can see the flat surface of the substance, or that the substance has no shape of its own but takes the shape of the container, and has a surface that can be seen. The child should say that the other substance in the bag is a solid and should describe a distinctive characteristic of a solid.

TASK 4 (Objective 3): Cut the rubber band that divides the two portions of the bag and have the child shake the bag so that the baking soda dissolves. Say, Tell me what kinds of substances—gas, liquid, solid—are in the plastic bag now. The child should state that both a liquid and a gas are in the bag.

Materials

Citric acid crystals, 1 container (*Module 39*)
Plastic bags, 3 (*Module 32*)
Rubber bands, 6
Baking soda, 1 container (*Module 39*)
Graduated cylinder, 1, 50-ml (*Module 39*)
Food coloring, 1 container (*Module 39*)
Containers, 2, 250-ml, clear plastic (*Module 39*)
Funnel, 1 (*Module 39*)

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MODULE
40

Inferring/b

How Certain Can You Be?

OBJECTIVES

At the end of this module the child should be able to

1. *DESCRIBE* new observations needed to test an inference.
2. *IDENTIFY* observations that support an inference.
3. *DISTINGUISH* between an inference that accounts for all of the observations and one that does not.

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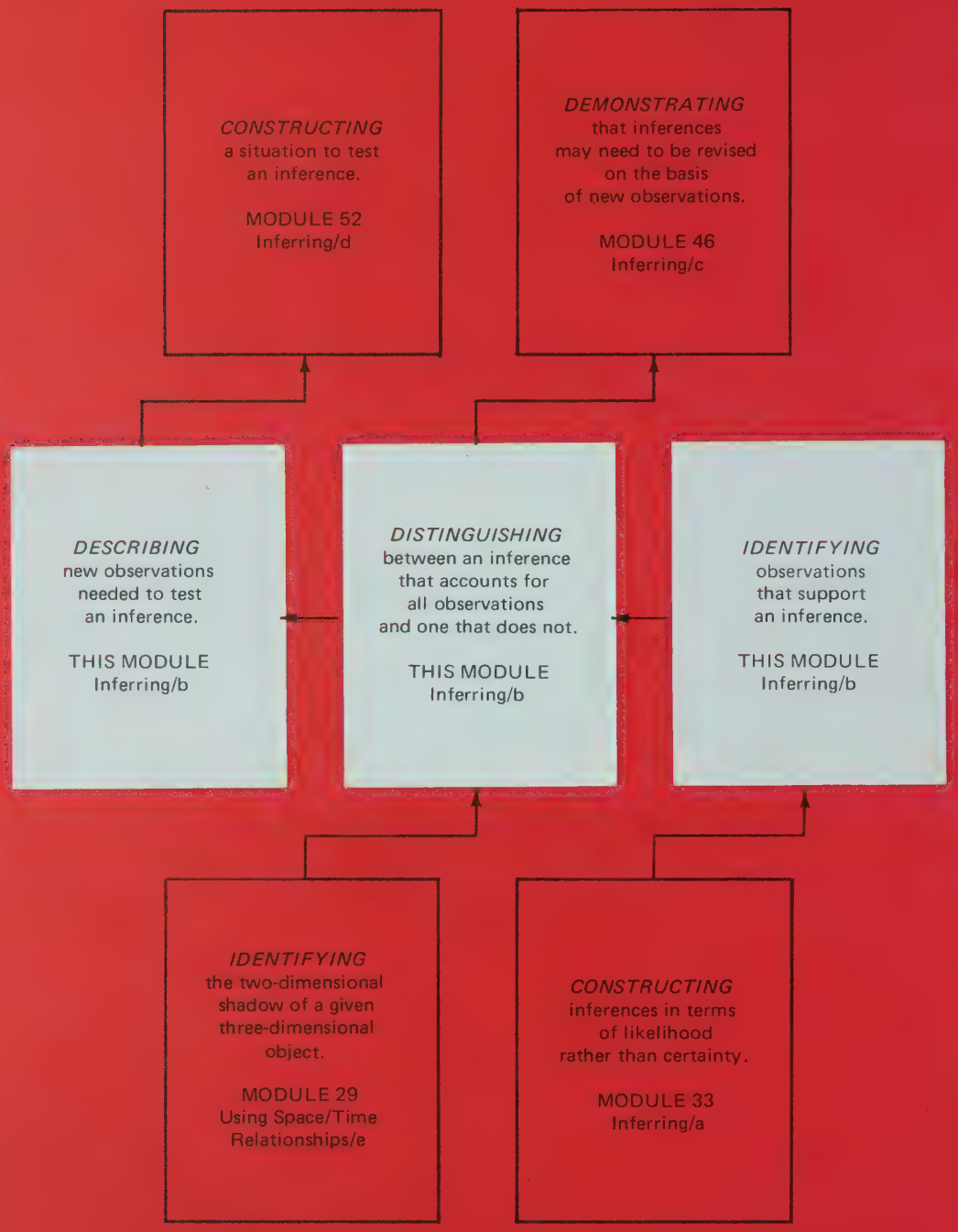
SEQUENCE



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0-663-30209-9

RATIONALE

In *What's Inside?, Inferring a, Module 33* the children learned to distinguish between observations and inferences and to construct inferences in terms of likelihood rather than certainty. The activities in this module are designed to extend the children's skill by requiring them to make inferences that account for and are supported by all the observations. They also learn that if they make as many observations as possible, their inferences become more reliable. However, emphasize that it is not possible to make sufficient observations so that inferences can be made in terms of absolute certainty.

You may find that the auto-instructional game *Shake and Peek* in *Activity 3* is too advanced for some of the children. If so, encourage them to come back to it at a later date.

Vocabulary

account for support

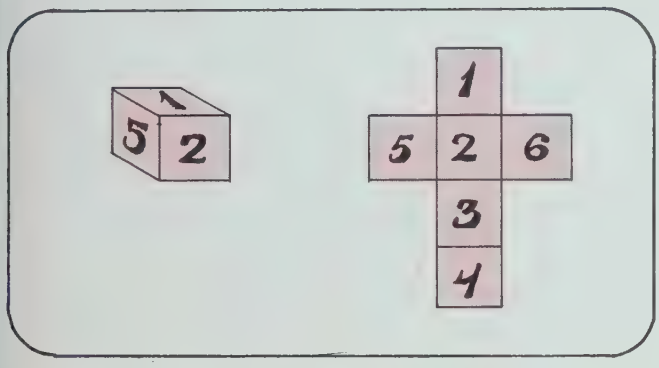

FIGURE 1

Advance Preparation

Before the children begin *Activity 3*, you will need to assemble several items that make up *Shake and Peek.* You have been supplied with six plastic cubes, labels for the cubes, the *Shake and Peek Box* to be assembled, and the *Empty Box* to be assembled. First cut out and place the labels on the cubes. One extra label for each cube has been supplied in case mistakes are made in labeling. It is important that the labeling be done carefully, according to the following directions. First, imagine that the faces of a cube have been numbered, and that the cube has then been opened up so that its six faces lie flat (see Figure 1). Place the appropriate labels on the faces of the cubes in the following way:

Cube A: Place the letter *A* labels on faces 1 and 2.
Cube B: Place the letter *B* labels on faces 1 and 3.
Cube C: Place the letter *C* labels on faces 1, 2, and 5.
Cube D: Place the letter *D* labels on faces 1, 2, and 3.
Cube E: Place the letter *E* labels on faces 1, 2, 3, and 4.
Shake and Peek Cube: Place the *?* labels on faces 1, 2, and 3.

To assemble the two boxes, refer to Figure 2. Place the *Shake and Peek Cube* inside the *Shake and Peek Box* and then close both ends of the box. Tape the ends shut so they will not fly open during the shaking. Place the *Shake and Peek* labels on this box. To assemble the *Empty Box* fold in the flaps at the end near the cutout corner. Tape this end shut. The other end remains open. Cut off the flaps at the open end so that it is easy for the child to put her or his hand into the box. Put the *Empty Box* labels in place.

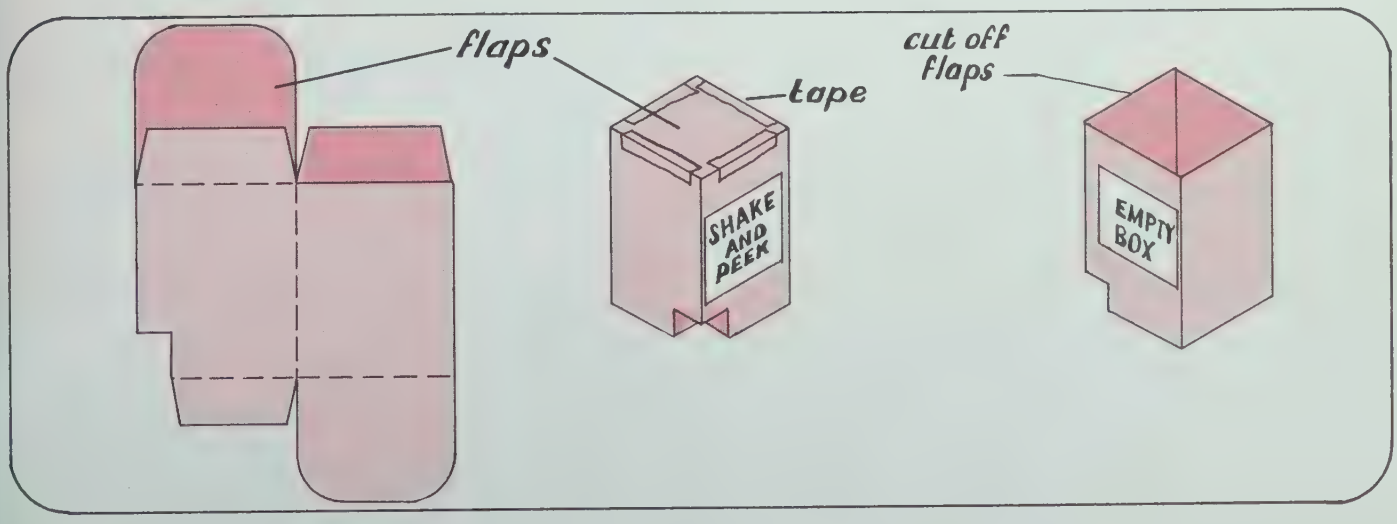

FIGURE 2

INSTRUCTIONAL PROCEDURE

Introduction

Show the children two containers—one filled with cooking oil and the other with liquid soap of the same color. Ask whether both containers hold the same substance. When the children respond, ask them why they believe as they do. Remind the children that observations are made by using the senses and that an inference is an explanation of the observations. Ask the children what observations they could make to determine whether these substances are the same. List the children's suggestions on the chalkboard. *CAUTION: Warn children never to taste an unknown substance.*

As each suggestion is made, let the child who made it carry it out and then state his observation. Ask another child whether the new observation supports the inference made earlier about the substances in the two containers. Continue this procedure until the children are satisfied that the substances are not the same. Point out again the uncertainty of the early inference and the confidence that results from more observations.

Materials

Containers, 2, 250-ml (*Module 39*)
Cooking oil, about 100 ml
Liquid soap, about 100 ml, the same color as the cooking oil

Activity 1

Set up six stations throughout the room; place two items at each station as shown in the chart that follows.

Station	Item A	Item B
1	marbles	marbles (same as Item A)
2	white sand	granulated sugar
3	shaving cream	whipped cream
4	brown sand	brown sugar
5	flour	flour
6	steel nail	aluminum nail

At an accessible place in the room set up a supply station with magnets, water, small containers, rulers, paste sticks, an equal-arm balance, and other materials that children may find useful when making observations.

Give each child a worksheet such as that shown in Figure 3. Explain to the children that they are to take turns going to each of the six stations. They may use the materials at the supply station to help them make observations about Item A and Item B at each station. They are to record these observations on the worksheets and then make an inference as to whether or not the two substances are the same. Remind the children not to use the sense of taste. Before the children actually begin the activity, you may wish to discuss how the materials in the supply station might be used. For example, you might ask the children how you could test a substance to see whether it is attracted by a magnet or whether it dissolves in water.

As the children move from station to station, you may need to remind them that the task is not to make inferences about the names of the substances, but rather to

OBSERVATIONS		INFERENCE
Station 1		
Item A Cannot be scratched with fingernail Weighs the same as B	Item B Cannot be scratched with fingernail Weighs the same as A	Are the substances the same? (Yes) No
Station 2		
Item A	Item B	Are the substances the same? Yes No

FIGURE 3

make an inference as to whether the substances are the same.

After the children have recorded their observations and inference for each pair of substances, ask different children to tell about their observations and their inference. Ask other children to identify those observations that support the inference. For example, in Figure 4, the second set of observations support the inference that the substances at Station 4 are not the same.

Materials

Containers, 12, 250-ml (*Module 39*)
Marbles, 10 (*Module 37*)
White sand, 1 package (*Module 40*)
Granulated sugar, 100 g
Shaving cream, 100 ml, from a pressurized can
Whipped cream, 100 ml, from a pressurized can
Brown sand, 1 package (*Module 40*)
Brown sugar, 100 g
Flour, 100 g
Steel nail, 1 (*Module 40*)
Aluminum nail, 1 (*Module 40*)
Magnets, 3 (*Module 40*)
Containers, 30, 30-ml (*Module 40*)
Metric rulers, 30 (*Module 34*)
Paste sticks, 30 (*Module 40*)
Equal-arm balance, 1, consisting of a base, balance arm, two balance pans, two pan halters, and two sliding compensators (*Module 42*)
Worksheets, 1 for each child, Figure 3
Pencils, 1 for each child

OBSERVATIONS		INFERENCE
Station 4		
Substance A Is brownish in color Does not dissolve in water	Substance B Is brownish in color Dissolves in water	Are the substances the same? Yes (No)

FIGURE 4

Activity 2 (Optional)

Set up five stations. At each station place paper, pencils, and a picture card on which a numbered sequence of activities is illustrated, with the fourth frame in the sequence left blank. Ask each child to draw, on a separate piece of paper, a picture of what he thinks would happen next—that is, what should go in the fourth frame of the picture card. Have each child do this at two or more stations. A small group of children could work at each station at the same time.

After the children's drawings have been completed, display the picture sequences and drawings that were prepared by the children. Pair the children into "evaluation teams," and ask each team to determine whether the ending drawn accounts for all of the observations that can be made for the first three pictures in the sequence. A large range of possible endings exists for each sequence. Let the children report and discuss their conclusions.

Materials

Pencils, 1 for each child
Drawing paper, 60 sheets
Fish or Play Ball?, 1, picture card (*Module 40*)
Dive In!, 1, picture card (*Module 40*)
Pine Forest, 1, picture card (*Module 40*)
Showing a Film, 1, picture card (*Module 40*)
The Garden, 1, picture card (*Module 40*)

Activity 3 (Optional)

This is an auto-instructional activity in which a child plays the game *Shake and Peek.* The child should require minimal supervision and should work alone. Give the child a copy of the booklet *Shake and Peek,* a copy of the *Answer Sheet,* and the materials necessary for playing the game. By the end of the game, the child will have made an inference, based on observations, that the number and position of plain faces of Cube D are identical to the number and position of plain faces of the cube in the *Shake and Peek Box.* If *Shake and Peek* is too difficult for some children, have them try the game again at a later time.

Materials

Shake and Peek, 1 booklet (*Module 40*)
Shake and Peek Answer Sheet, 5 spirit masters (*Module 40*)
Shake and Peek Box, 1 (*Module 40*)
Empty Box, 1 (*Module 40*)
Shake and Peek Cubes, set of 6 to be labeled (*Module 40*)
Labels, 1 set for *Shake and Peek Boxes* and *Cubes* (*Module 40*)
Magic pens, 4 (*Module 40*)

Generalizing Experience

Prepare the following without letting the children see you do it.

1. Six empty eggshells. Remove each raw egg by making a small hole at each end of the eggshell. Blow in one end; this will cause the raw egg to come out the other end. Wash the hollow shell with soapy water, allow to dry, and seal the holes with paraffin.

2. Eighteen hard-boiled eggs. With a felt tipped pen, place a large X on six of the hard-boiled eggs, leaving twelve unmarked.

Divide the children into groups of five. Give each group a dish holding a set of four eggs: one empty eggshell, one hard-boiled egg marked with an X, and two unmarked hard-boiled eggs.

Ask the children to list on a sheet of paper their observations and their inferences about the eggs. Have groups exchange observations and inferences. Ask the children whether their inferences account for all the observations and whether the inferences are supported by all the observations.

Hold up an egg and say, "This is a hard-boiled egg." Ask them whether that statement is an inference or an observation. After the children have decided that the statement is an inference, hold up the same egg and say, "This is a raw egg." Ask the children what additional observations they would need to make in order to choose between these two inferences.

Materials

Eggs, 24, 6 empty eggshells and 18 hard-boiled eggs
Dishes, 5, each large enough to hold 4 eggs
Pencils, 1 for each child
Writing paper, 1 sheet for each child

APPRAISAL

Relate the following incident to the children.

"Tom was walking to school early one windy morning. As he walked along the busy street, he heard a loud banging noise. He looked around and saw an overturned garbage can. Then he saw a big yellow and white cat running away from the garbage can. He also saw a dog chasing the cat."

On the chalkboard put these two inferences.

1. The cat may have run into the garbage can and overturned it.
2. I think the wind upset the garbage can.

Ask the children which of these two inferences accounts for all of Tom's observations. Then ask which observations support Inference 1 and which support Inference 2.

The children should respond that Inference 1 accounts for all of the observations; Inference 2 accounts for some of the observations, but does not explain the actions of the cat and dog.

Observations

1. The object smells like a flower.
2. The object can be held in my hand.
3. The object is slippery when wet.
4. The object weighs more than a man.
5. The object is white.

Inference

The object might be a bar of soap.

FIGURE 5

Observations

1. Box *B* feels much heavier than Box *A*.
2. Something inside rattles when I shake Box *B*.
3. Box *B* is bigger than a quarter.
4. Box *B* has no odor.

Inferences

1. There might be a piece of rock in Box *B*.
2. There might be a paper clip in Box *B*.

FIGURE 6

COMPETENCY MEASURE

TASK 1 (Objective 1): Read the following sentences to the child. **Two children were walking along the street. One said to the other, "Oh, look, there's a magnet under the hedge." The other child said, "Well, it looks like a magnet, but it may not be, because. . ."** Ask, **How could the two children test the inference that the object is a magnet?** The child should describe a reasonable test, for example, "They could pick up the object and see if it attracts an iron object like a magnet does."

TASK 2 (Objective 2): Give the child a copy of the list shown in Figure 5. Read the observations and the inference to the child. Say, **Put an "X" in front of the observations that support the inference.** The child should mark Observations 1, 2, 3, and 5.

TASK 3 (Objective 3): Show the child two sealed paper clip boxes, *A* and *B*. Box *A* is empty and *B* contains a small but heavy rock or marble. Give the child a copy of the list of observations and inferences shown in Figure 6. Read the observations and inferences to the child. Then ask, **Which inference is better? Why?** The child should answer that Inference 1 is better because Inference 2 does not account for the observation that Box *B* is much heavier than Box *A*.

Materials

Paper clip boxes, 2

(Note: Label one box *A*; label the other box *B* and place a marble or small, heavy rock inside it.)

Pencils, 1 for each child

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40 Inferring/b

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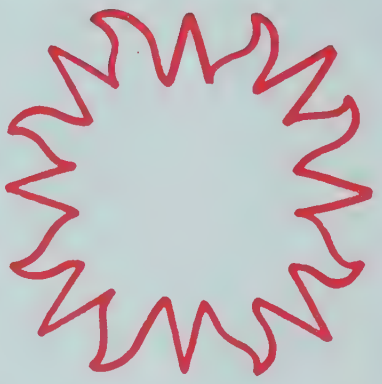

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SCIENCE... A PROCESS APPROACH II

MODULE

41

Measuring/h

Temperature and Thermometers

OBJECTIVES

At the end of this module the child should be able to

1. *DEMONSTRATE* how to use a thermometer to measure the temperature of a gas or liquid.
2. *NAME* the temperature of a given gas or liquid to the nearest degree Celsius.
3. *DEMONSTRATE* how to use a thermometer to measure changes in temperature.
4. *NAME* observed changes in temperature in degrees Celsius.

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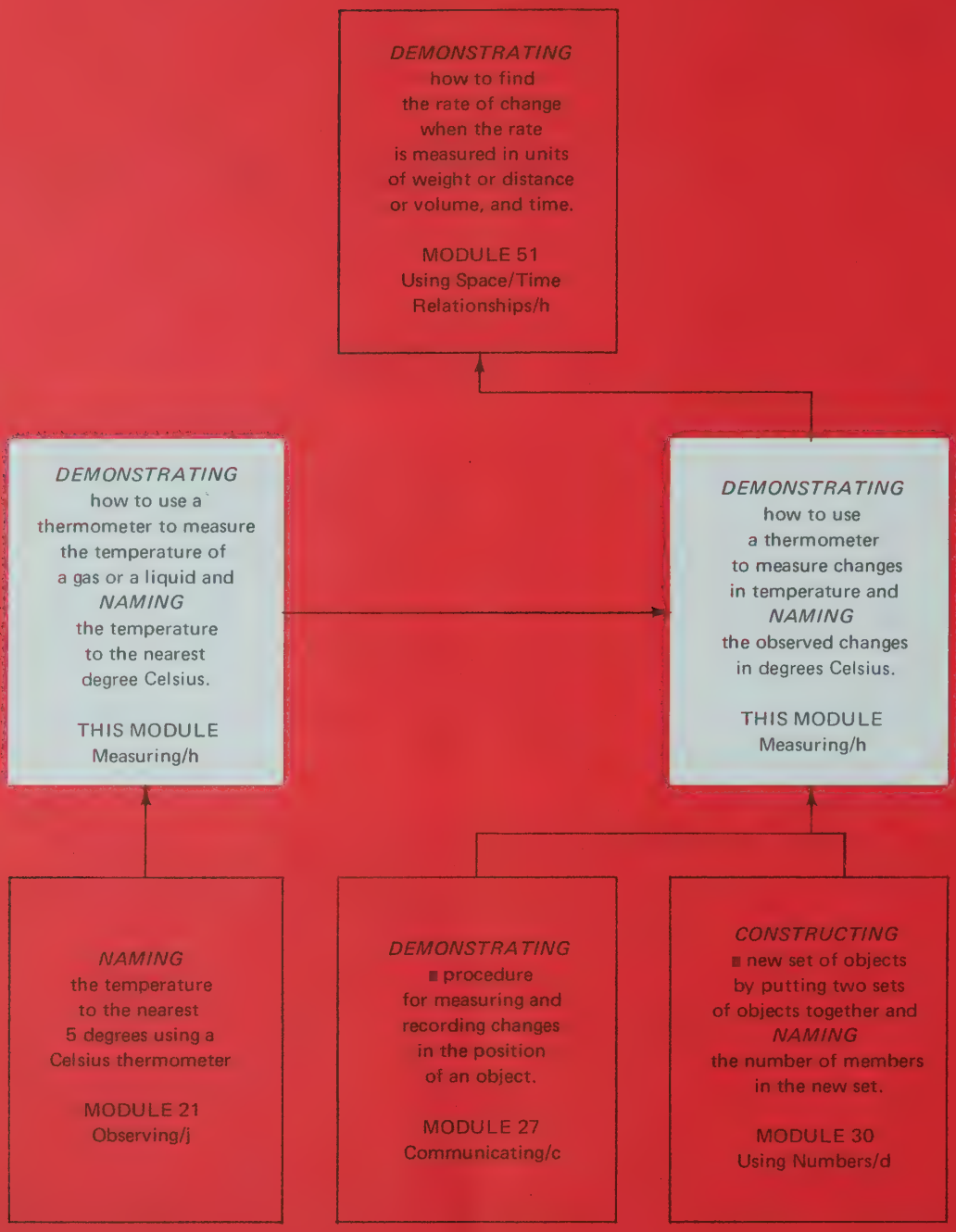
SEQUENCE



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RATIONALE

Temperature is a basic scientific concept as well as an everyday concern. Everyone "knows" what temperature is, but not everyone can give it a precise, scientific definition. For young children, a perfectly adequate definition is that temperature is the hotness or coldness of an object (including the air).

In *Weather, Observing j, Module 21,* the children learned to read the thermometer scale to the nearest 5 degrees Celsius. In the present module, the children continue to develop skill in using a thermometer. The children measure the temperature of air and water in various places and under different conditions; they measure at regular intervals the temperature of liquids as the liquids are warmed or cooled. As the children are performing these and other activities, they increase their ability to read the thermometer scale quickly and accurately, now to the nearest degree Celsius. In activities in which the children measure temperature changes, you might encourage them to tell how much the temperature changed. This will help them develop skills in subtraction.

The metric temperature scale, formerly called centigrade, is now called the Celsius scale in honor of the man who invented it in the eighteenth century. The Celsius scale, used universally in scientific work, is also the scale in general use in most countries. For further information about the Celsius scale, see the Science Background Papers "The Metric System" and "Measuring Temperature and Heat" in the *Commentary for Teachers.*

Vocabulary

thermometer	scale
temperature	freezing point
degree	negative number
Celsius	boiling point (optional)

INSTRUCTIONAL PROCEDURE

Introduction

Give each child a Celsius thermometer. *CAUTION: Remind the children to handle the thermometers carefully. Even though the glass tube is protected by a plastic back, the glass can be broken if the thermometer is handled roughly or dropped on the floor.* If a thermometer is dropped but not broken, and the liquid column separates, dip the thermometer into a dry ice/alcohol mixture or place it in the freezer section of a refrigerator overnight.

Have the children examine their thermometers for a few minutes and then tell what they have observed. Ask the children what a thermometer can be used for and how it is used.

Put out several alphabetically labeled containers of water at different temperatures. Give each child a pencil and a sheet of paper. Have the children use their thermometers to measure the temperature of the water in the different containers and of the air in various parts of the room. (See Figure 1.) Ask the children to record two things each time they make a measurement: (1) the temperature, and (2) the container or the part of the room where the temperature was measured. Let the children name the temperature with whatever accuracy they can. In subsequent activities they will learn to read temperature to the nearest degree Celsius.

Materials

Thermometers, 30, Celsius, ⁻20° to 110° (*Module 41*)
Containers, several, 250-ml, of water at different temperatures, labeled *A, B, C,* etc. (*Module 39*)
(Note: Use tap water of various temperatures.)
Paper, 1 sheet for each child
Pencils, 1 for each child

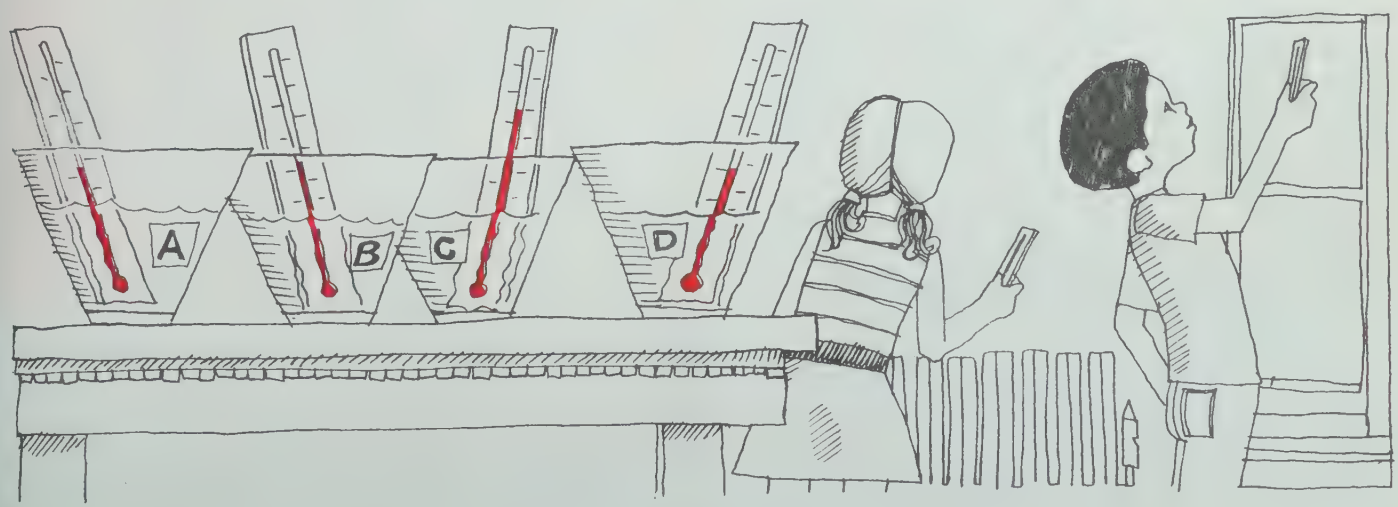

FIGURE 1

Activity 1

Ask the children what measurements they made with their thermometers. You might want to tabulate on the chalkboard the air and water temperatures measured by different children. Different temperature readings should lead to discussion of whether the water and air temperatures remained the same or changed; whether the thermometers were left long enough at each place; and whether all thermometers give the same reading (there may be differences of one-half degree or so among readings on several thermometers in the same container of water).

You may find that some children are not sure how to read their thermometers. The following activity should help them and serve as a good review for the others.

Project the transparency *Practice Thermometer.* Be sure that the children can see the degree markings. With a red transparency marker, color in the thermometer tube so that the top of the red stripe is on a numbered degree mark. Ask what temperature is represented. Repeat this procedure several times until the children can name the indicated temperatures quickly. Next, have the children practice naming the temperature when the top of the red stripe is at an unnumbered degree mark.

Now color the stripe so that the top lies between two degree marks, and ask the children what temperature is shown. After some discussion, suggest this rule: When the top of the red stripe falls between two degree marks, read the number of degrees at the nearer mark. Let the children practice applying this rule. If concern develops over what to call the temperature when the stripe appears to stop midway between degree marks, suggest that the children decide which degree mark to read, and that they follow their rule consistently. If some children want to say, "ten and a half," for instance, encourage them to do so. Do not insist, however, that all the children do this.

Pairs or small groups of children might practice among themselves by drawing pictures of thermometers, one child drawing the red stripe and another child naming the temperature. Or one child might name a temperature and the other child draw the stripe to indicate that temperature. The children might also practice with the *Temperature Chart* supplied in *Module 21.*

Materials

Thermometers and containers from *Activity 1*
Practice Thermometer, 1 transparency (*Module 41*)
Transparency marker, 1, red, such as washable felt-tipped pen
Drawing paper, several sheets for each child (optional)
Crayons, 1 for each child, red (optional)
Pencils, 1 for each child (optional)
Temperature Charts, 3 (optional) (*Module 21*)

Activity 2

Divide the children into groups of three or four. Give each child a Celsius thermometer, and provide each group with a clear plastic container of crushed ice. Ask the children to measure the temperature of the ice. As the children are waiting for the liquid column in the thermometer to stop falling, some of the ice will melt. Therefore, although the temperature of the ice/water mixture should be 0°C, the children may get readings between 0°C and 5°C.

Ask the children to report their readings to you. If you wish, record some or all of the readings on the chalkboard. Tell the children that the thermometers they are using are marked with the *Celsius scale,* that on the Celsius scale the temperature of a mixture of ice and a little water is 0°, and that 0°C is the temperature of the *freezing point* of water. Ask what the room temperature is on the Celsius scale. (About 23°C.) Then ask whether room temperature is always the same. If there is any disagreement, have the children record the room temperature at different times during the day. Explain that room temperature may change, but the temperature of crushed ice mixed with a little water is always 0° on the Celsius scale. You might also tell the children that 100° on the Celsius scale is the temperature of the *boiling point* of water.

Materials

Thermometers, 30, Celsius, ⁻20° to 110° (*Module 41*)
Containers, 10, 250-ml (*Module 39*)
Crushed ice, 1 bag, enough to fill the 10 containers

Activity 3

Divide the children into groups of three. Give each child a thermometer and provide each group with three containers, as described in *Materials.* Also give each group a copy of *Temperature Scales* showing a series of number lines. Suggest that one child in each group measure and record on a number line the temperature of the hot water, and another the temperature of the cold water. Those two children should then simultaneously pour their water into the larger container. The third child should measure and record on the same number line the temperature of the mixture. The information they collect might appear as shown in Figure 2.

Have the children repeat this procedure several times using water of different temperatures, such as 5° and 30°, 20° and 40°, and so on. As the children mark their results on the number lines, they may notice that the temperature of the mixture is halfway between the temperatures of the hot and cold water, provided the volumes of hot and cold water are the same.

Children who do discover the above relationship might like to try mixing different volumes of water measured with a graduated cylinder—for example, 50 milliliters of hot water and 20 milliliters of cold water—to see whether the temperature of the mixture is still midway between the high and low temperatures. (It is not.)

Another instance when the water mixture will not be at the halfway mark will occur when hot water is mixed with an equal volume of cold water with ice in it. The temperature of the mixture will be lower than the mid-point.

Materials

Thermometers, 30, Celsius, ¯20° to 110° (*Module 41*)
Containers, 10, 250-ml, one per group (*Module 39*)
Containers, 20, 120-ml, 10 with 50 ml of hot water (40° – 50°C), and 10 with 50 ml of cold water (0° – 15°C); one of each type per group (*Module 41*)
(Note: Use tap water for the hot and cold water.)
Temperature Scales, 1 spirit master (*Module 41*)
Pencils, 1 for each child
Graduated cylinders, 4, 50-ml (optional) (*Module 39*)

FIGURE 2

Activity 4

Group the children into threes, and give each group a Celsius thermometer, a 250-milliliter plastic container one-quarter filled with crushed ice, and about 20 grams of table salt in a dry plastic container. Tell the children you would like them to add some of the salt to the crushed ice, and then measure the temperature of the mixture. Suggest that they stir the ice/salt mixture slowly and carefully with the thermometer. The children might take turns stirring the mixture and reading the temperature. Ask them to find out the lowest temperature they can get by adding salt to the ice. (The lowest should be below zero.) Reassure the children that the thermometer will not break if the red liquid falls to the lower end of the tube.

Have the children report their results. Ask them how they might name temperatures that are colder than zero. Some may suggest calling those temperatures "degrees below zero." Draw a number line on the chalkboard with numbers on both sides of zero, but without negative signs. Ask how the numbers on the two sides of zero are written. Negative numbers were discussed in *Numbers and the Number Line, Using Numbers c, Module 20.* But if the children have forgotten, distribute number lines similar to that shown in Figure 3, and review with the children the term *negative number* and the customary notation of a raised negative sign.

Interested children might want to continue to try to find the coldest possible temperature of the ice/salt mixture. They could vary the size of the ice (cubes, large chunks, crushed), the type of salt (table salt, rock salt), the amount of salt used, and so on. Do not try to explain why the temperature of a mixture of salt and ice is lower than 0°C. You might mention, however, that salt is sometimes used to melt ice on sidewalks and roads, and to lower the temperature of the ice used in making ice cream.

Materials

Thermometers, 10, Celsius, ¯20° to 110° (*Module 41*)
Containers, 10, 250-ml (*Module 39*)
Crushed ice, 1 bag, enough to fill the 10 containers
Table salt, 1 container (*Module 41*)
Containers, 10, 120-ml, to hold table salt (*Module 41*)
Number lines, showing positive and negative numbers as in Figure 3, 1 for each child (optional)

FIGURE 3

Activity 5

Divide the children into groups of three. Give each group a Celsius thermometer, an ice cube, and a plastic container holding about 100 milliliters of water at room temperature. Also give each group a pencil and a sheet of paper. Tell the children that they will be putting the ice cube into the water and then measuring the temperature of the water every minute thereafter.

Suggest for each group that one child stir the water/ice mixture carefully with the thermometer, one child call "time" every minute, and one child record the number of minutes and the temperature. Suggest that the groups first measure and record the temperature of the water without the ice cube. Then, when the second hand reaches *12* on the wall clock, they should put the ice cube into the water. Each time the second hand reaches *12* again, they should read and record the temperature. Have the children do this for at least 5 minutes.

After the groups have collected data for 5 minutes or more, give each child a sheet of graph paper on which to make a bar graph representing the data recorded by the group. The graphs should show the water temperature before the ice cube was put in the water and at the end of each minute thereafter for at least five minutes. You may have to review graphing skills with some of the children. (See *Introduction to Graphing, Communicating b, Module 25*, and Using *Graphs, Predicting a, Module 38*.) The completed graphs might look something like that shown in Figure 4.

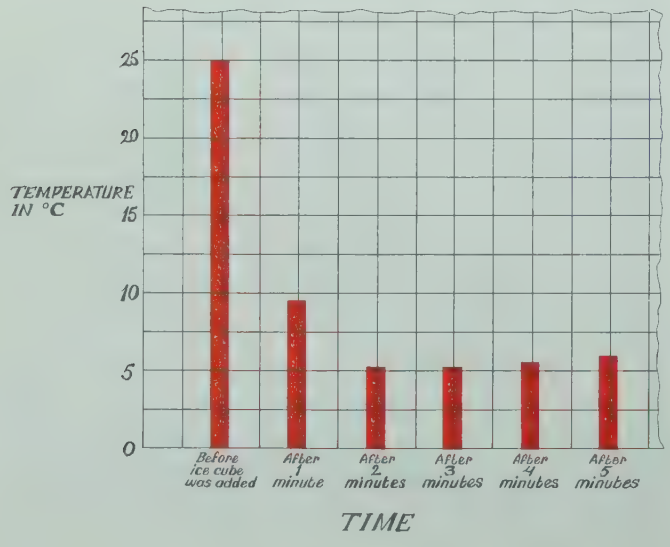

FIGURE 4

Encourage the children to discuss their observations and their graphs. During the discussion, the children should express temperature change by naming initial and final temperatures for particular time periods. They might also tell how many degrees the temperature changed, or the difference between the initial and final temperatures. Ask such questions as the following if the children have not already included the ideas in their discussion.

During which minute did the water cool most quickly?
When was the lowest (coldest) recorded temperature?
When was the ice cube completely melted?
Why did the water begin to warm up?

Materials

Thermometers, 10, Celsius, ¯20° to 110° (*Module 41*)
Ice cubes, 10
Containers, 10, 120-ml (*Module 41*)
Water, 1 liter, at room temperature
Wall clock or timer
Paper, 10 sheets, for recording data
Pencils, 1 for each child
Graph Paper, 1 spirit master (*Module 41*)

Generalizing Experience

Keep a few thermometers handy so that children can use them frequently to measure temperatures of liquids, of the air, of the soil in pots where plants are growing, and so on.

Another enjoyable activity would be to make ice cream with a hand- or electric-powered freezer, using a rock-salt and crushed-ice freezing mixture. The children could measure the temperature of the freezing mixture at regular intervals. They could also measure the temperature of the ice-cream mixture before it is put in the freezer and after it has become ice cream.

Materials

Thermometers, 10, Celsius, ¯20° to 110° (*Module 41*)
Freezer, 1, hand- or electric-powered (optional)
Rock salt, 1 box, for ice-cream freezer (optional)
Crushed ice, 1 bag, for ice-cream freezer (optional)
Ice cream ingredients, found in most cookbooks (optional)

APPRAISAL

Have the children, individually or in small groups, measure the temperature of the air at places you specify, such as over a radiator, in the sun by the window, outside in the sun, or outside in the shade. Ask the children to tell you the temperature to the nearest degree Celsius.

Show the children how to attach a wad of wet paper towel or newspaper over the bulb of a thermometer with a rubber band. Ask the children, individually or in small groups, to put wet paper on their thermometer bulbs, hold the bulbs in front of an electric fan as in Figure 5, and measure and record any observed changes in temperature. If an electric fan is not available, a paper fan or a piece of cardboard will suffice.

Ask the children to tell you how the temperature changed and how much it changed. In saying how much the temperature changed, the children need only state the initial and final temperatures. They might, however, extend their answer to indicate the number of degrees difference between those two temperatures.

As the water in the wad of paper evaporates in the stream of air, the wet paper becomes cooler. If any of the children think it is simply the moving air that is cooling the thermometer, suggest that they put a dry paper towel or newspaper on the thermometer bulb, repeat the procedure, and compare the results.

Materials

Thermometers, 30, Celsius, ¯20° to 110° (*Module 41*)
Paper towels or newspapers
Fan, 1, electric, or paper fan or piece of cardboard
Paper, 1 sheet for each child, to record data
Pencils, 1 for each child

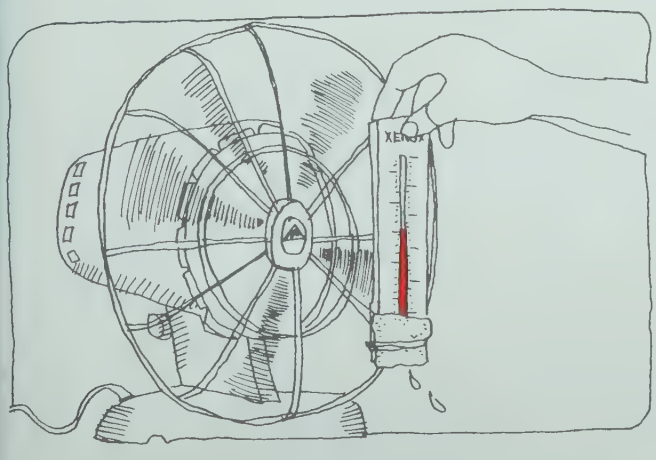

FIGURE 5

COMPETENCY MEASURE

TASK 1 (Objective 1): Give the child a Celsius thermometer and a cup of hot tea, and say, **Show me how to use the thermometer to measure the temperature of the tea.** The child should put the bulb of the thermometer into the tea, wait until the red liquid stops moving upward, and be ready to read the temperature.

TASK 2 (Objective 2): Ask, **What is the temperature of the tea?** The child should name the temperature to the nearest degree Celsius.

TASK 3 (Objective 3): Put about 50 milliliters of water at room temperature in a glass custard cup, and put the container on a ring stand. Light a candle. Give the child a thermometer, a sheet of paper, and a pencil, and say, **I am going to put the candle under the container of water. I will tell you the time every minute. I would like you to keep a record of the temperature of the water each minute. First, measure and record the temperature of the water before I put the candle under it.** After the child has measured and recorded the temperature of the water, put the candle under it and note the time. At the end of one minute, say, **one minute,** at the end of two minutes, **two minutes,** and so on, for at least three minutes. The child should measure and record the temperature to the nearest degree Celsius each minute.

TASK 4 (Objective 4): Say, **Tell me how much the temperature changed.** The child should name the initial and final temperatures, or the difference between them.

Materials

Thermometer, 1, Celsius, ¯20° to 110° (*Module 41*)
Hot tea, 3 cups
Custard cup, 1, glass, heat-resistant
Water, 150-ml, at room temperature
Ring stand, 1, consisting of ring (*Module 41*) and support stand (*Module 37*)
Candle, 1 (*Module 41*)
Matches, 1 package
Paper, 1 sheet for each child
Pencils, 1 for each child
Wall clock or timer

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41 Measuring/h

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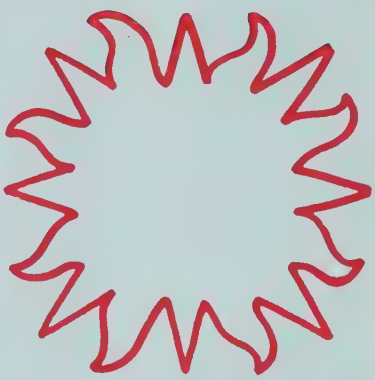

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SCIENCE... A PROCESS APPROACH II

MODULE

42

Classifying/e

Sorting Mixtures

OBJECTIVES

At the end of this module the child should be able to

1. *DEMONSTRATE* a specified method for classifying components in a given mixture according to the size of the particles of the components.
2. *ORDER* the components of a mixture according to the size of the particles of the components.
3. *ORDER* the components of a mixture according to the amount (volume or weight) of each component.

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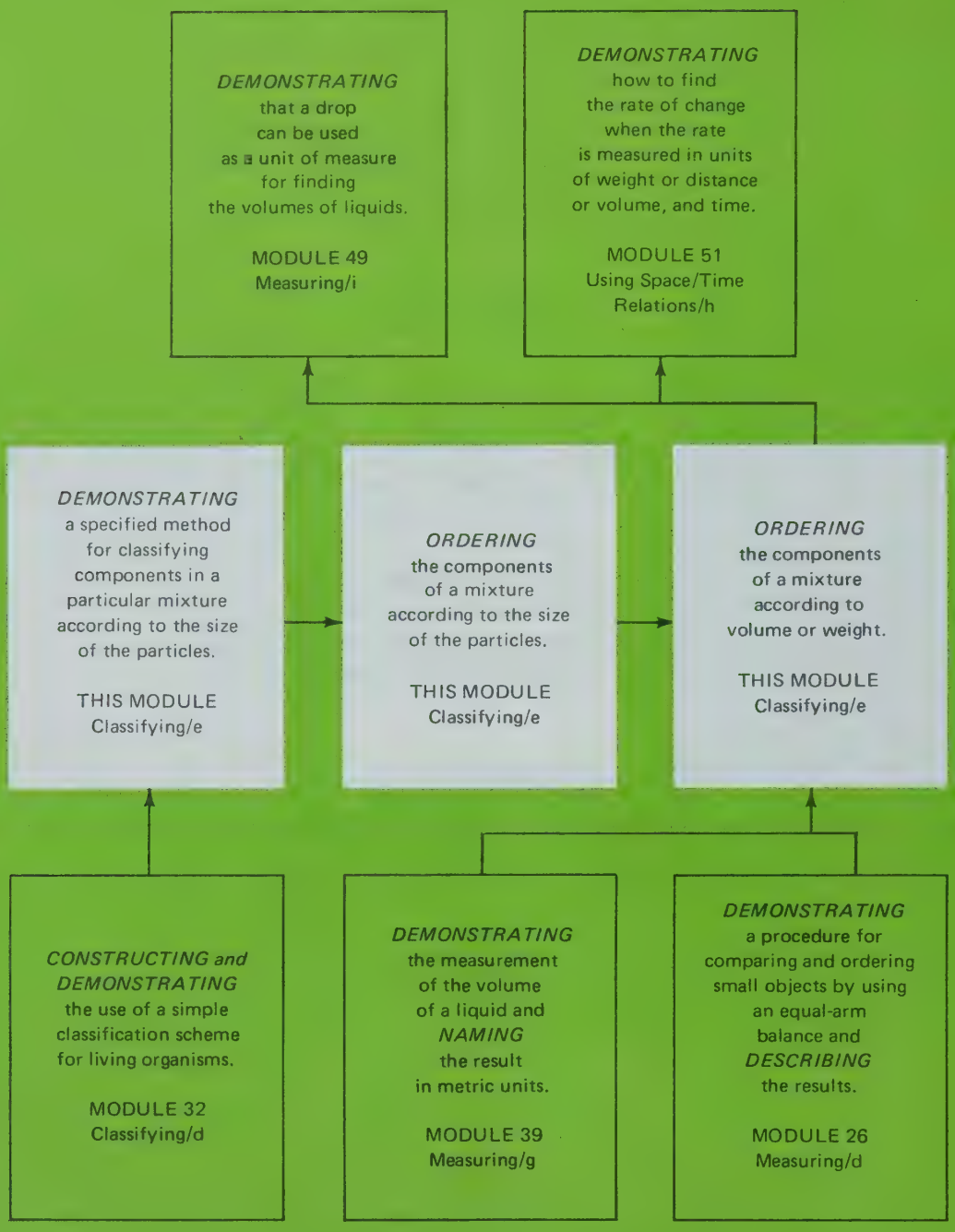
DEMONSTRATING that a drop can be used as a unit of measure for finding the volumes of liquids.
MODULE 49 Measuring/i
DEMONSTRATING how to find the rate of change when the rate is measured in units of weight or distance or volume, and time.
MODULE 51 Using Space/Time Relations/h
DEMONSTRATING a specified method for classifying components in a particular mixture according to the size of the particles.
THIS MODULE Classifying/e
ORDERING the components of a mixture according to the size of the particles.
THIS MODULE Classifying/e
ORDERING the components of a mixture according to volume or weight.
THIS MODULE Classifying/e
CONSTRUCTING and DEMONSTRATING the use of a simple classification scheme for living organisms.
MODULE 32 Classifying/d
DEMONSTRATING the measurement of the volume of a liquid and *NAMING* the result in metric units.
MODULE 39 Measuring/g
DEMONSTRATING a procedure for comparing and ordering small objects by using an equal-arm balance and *DESCRIBING* the results.
MODULE 26 Measuring/d

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173,

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RATIONALE

In earlier modules in the classifying process, the children classified objects on the basis of one or more characteristics such as color, shape, and use. In this module they classify components of a mixture by size, weight, and volume. In *Activity 1* the children sort marbles according to size by hand, and then use a sorting device called an expanding trough. In other activities the children use not only the expanding trough, but also other sorting devices such as the graded-screen trough and the graded-screen sieves. These sorting devices might be called "classifying machines." With them the children can separate—that is, classify by size—components of mixtures that would be difficult and time-consuming to sort by hand. (See Figure 1.)

In addition to classifying the components of mixtures by size, the children measure the amount of each component, by volume in *Activity 2* and by volume and weight in *Activity 3*. These activities provide a simple introduction to an important scientific analytical process—determining the percentage composition of a substance or a mixture of substances.

Vocabulary

component	trough
mixture	particles
sort	sieve
expanding	

FIGURE 1

INSTRUCTIONAL PROCEDURE

Introduction

Put some coarse gravel, pea gravel, coarse sand, and fine dry clay in a container. Shake the container to mix the materials. Ask the children how they could find out how much coarse gravel is in the mixture. The children may suggest picking out the gravel. If so, point out to them that it might take quite a while to do this, but it is possible. Ask them how they could find the weight of the sand and of the clay in the mixture. Separating the sand from the clay by hand might be possible, but it would take a great deal of time. Tell the children that later on you are going to show them an easy way to separate the gravel, sand, and clay, but that first you want them to separate the components of a mixture that can be sorted by hand.

Materials

Gravel, 1 bag, coarse (*Module 42*)
Gravel, 1 bag, pea (*Module 42*)
Sand, 1 bag, coarse (*Module 39*)
Clay, 1 bag, dry, fine (*Module 42*)
Container, 1- or 2-liter, with cover

FIGURE 2

Activity 1

Show the children a large bag of 270 marbles, and inform them that the bag contains three different sizes of marbles. Tell the children that you would like them to separate the marbles, putting them into three central containers, one for each size. Tell the children that you would like to know how long the job takes.

Divide the children into five groups. Then divide the marble mixture, putting an equal number of marbles into five shoe boxes and making sure that each box contains a number of marbles of each size. Give each group of children a box of marbles and three smaller boxes for separating the marbles of each size (see Figure 2). Have each group choose a timekeeper. The timekeeper should calculate the time required to separate the marbles, from the time the children begin sorting the marbles to the time when they put the marbles into the central containers. As each group finishes its sorting, have members of the group empty each small box of marbles into one of three central containers. Make sure the children understand what they are to do before the timing begins.

When all five groups have finished, ask each timekeeper to record the group's time on the chalkboard. With the children's help, calculate the total time it took all the children to sort all of the marbles.

Ask the children what they think of the way they just sorted the marbles, and if they can think of a faster way to sort the marbles.

Show the children the expanding trough. Put the trough on a table so that it is clearly visible to all the children. Place three containers under the trough to catch the marbles as they fall through. (See Figure 3.) Roll a large marble down from the elevated narrow end. Discuss with the children why the marble falls out where it does, how the trough might be used to separate the marbles, where the three plastic containers should be placed, and so on. Ask two children to separate the marbles again by carefully pouring them from the bag into the narrow end of the trough. Have the other children record the starting and finishing times.

Ask the children how long it took to separate the marbles this time, and how this length of time compares

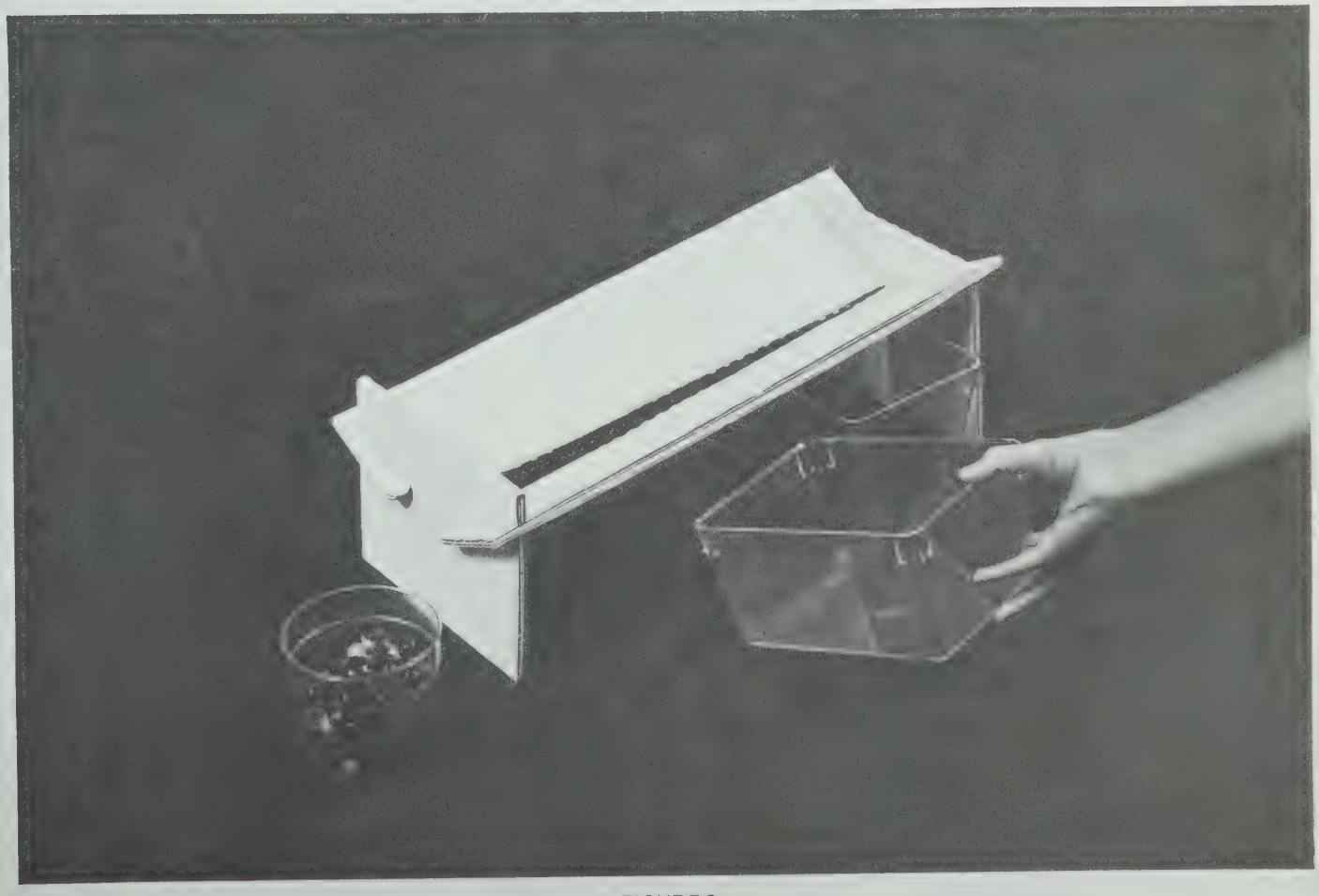

FIGURE 3

with the total length of time it took all of the children to separate the marbles. Emphasize that fewer people did the sorting in a shorter period of time.

To give more children an opportunity to use the device, leave it and the marbles where the children can work with them during their free time. If other sizes of small balls are available, add these to the mixture and have other containers available for the children to place under the trough.

After all of the children have had an opportunity to use the expanding trough, ask them what the process of separating the marbles, whether by hand or with the trough, is called. Some may say sorting. If no one says classifying, ask the children if the process of separating the marbles could be called classifying. Everyone should agree that they have been classifying the marbles according to one characteristic—size. Suggest to the children that the expanding trough might be called a "classifying machine."

Materials

Marbles, 60, large (*Module 42*)
Marbles, 90, medium (*Module 42*)
Marbles, 120, small (*Module 42*)
Bag, 1, large, clear plastic, heavy-duty, to hold the 270 marbles
Shoe boxes, or similar containers, 8, to hold marbles
Small boxes, 15, such as children's milk cartons from cafeteria
Expanding trough, 1 (*Module 42*)
(Note: Put cellophane tape on both inside edges of the opening of the trough so that the edges will be smooth and the marbles will roll easily.)
Containers, 3 or 4, 500-ml, plastic (*Module 42*)
Wall clock or timer, 1, with sweep-second hand
Balls, several, small, to add to marble mixture (optional)

Activity 2

Show the children a dry mixture of pea gravel, coarse sand, and fine sand. Discuss with them the problems involved in separating the mixture into its component parts without a "classifying machine." Ask the children if the expanding trough will do the job in this case. If some children wish to try it, let them. Have them report their observations to the whole group. Then show the children a graded-screen trough. Discuss with them how it could be used as a "classifying machine" for the mixture of sand and gravel.

Set the trough up as in Figure 4 with sheets of paper under the trough on which the different components of the mixture can fall.

Give a small demonstration group of three or four children a container with the mixture and several 50-milliliter graduated cylinders. Have the group measure the volume of the mixture using the graduated cylinders and record the measurement on the first line of the data table (see Figure 5) that has been drawn on the board. Next ask the group to pour the mixture into the top of the trough, and, if necessary, shake the box slightly so that the mixture slides down the trough over the screens. When all the mixture has sifted through the screen, the children can measure the volume of one of the component parts using the graduated cylinders. Then they should record the volume in the table. (Please note that the measurements shown in Figure 5 are arbitrary. Measurements will depend on your mixture.) Do not complete the measurements at this time, but inform the children that all of them will be asked to separate and measure the volume of another mixture themselves at a later time (*Activity 3*).

The children will probably notice that separation is not complete. Fine particles tend to cling to the larger ones, to the screening, and in the corners.

Materials

Gravel, 1 bag, pea (*Module 42*)
Sand, 1 bag, coarse (*Module 39*)
Sand, 1 bag, fine (*Module 42*)
Expanding trough, 1 (*Module 42*)
Graded-screen trough (*Module 42*)
Paper, several sheets
Container, 1, 500-ml (*Module 42*)
Graduated cylinders, 2, 50-ml (*Module 39*)

FIGURE 4

MATERIAL	VOLUME, in milliliters
1. mixture	300
2. pea gravel	
3. coarse sand	120
4. fine sand	
5. sum of 2,3,4	

FIGURE 5

Activity 3

Remind the children of the mixture of gravel, sand, and clay that you showed them in the *Introduction*. Ask the children questions such as the following: Could you use the expanding trough to separate the mixture? (It would sort the gravel from the sand and clay, but not the clay from the sand.) What about the trough with the different meshes of screen? (It would be better, but the clay and the sand might still be mixed up together.) What do you need to separate the mixture? (Something that will hold the sand and let the fine clay through.)

Show the children a set of graded-screen sieves. Hold the sieves up two at a time so that everyone can see that the bottoms are different. (See Figure 6.) Each sieve has holes of a different size. Also show the children the container with the solid bottom. Ask the children if they think the equipment might be used as a "classifying machine" to separate the gravel, sand, and clay. Ask those who respond positively how they would use the equipment. Their replies should include the idea that they could start with the sieve having the smallest holes, then use the next larger, and so on; or they could start with the sieve having the largest holes, then the next smaller, and so on.

Divide the children into two groups. Call one *Group A* and the other *Group B*. Then divide each group into teams of three or four children. *Group A* will be separating a mixture of coarse gravel, pea gravel, coarse sand, and dry clay using the nesting sieves, while *Group B* will use the graded-screen troughs to separate a mixture of pea gravel, coarse sand, and fine sand.

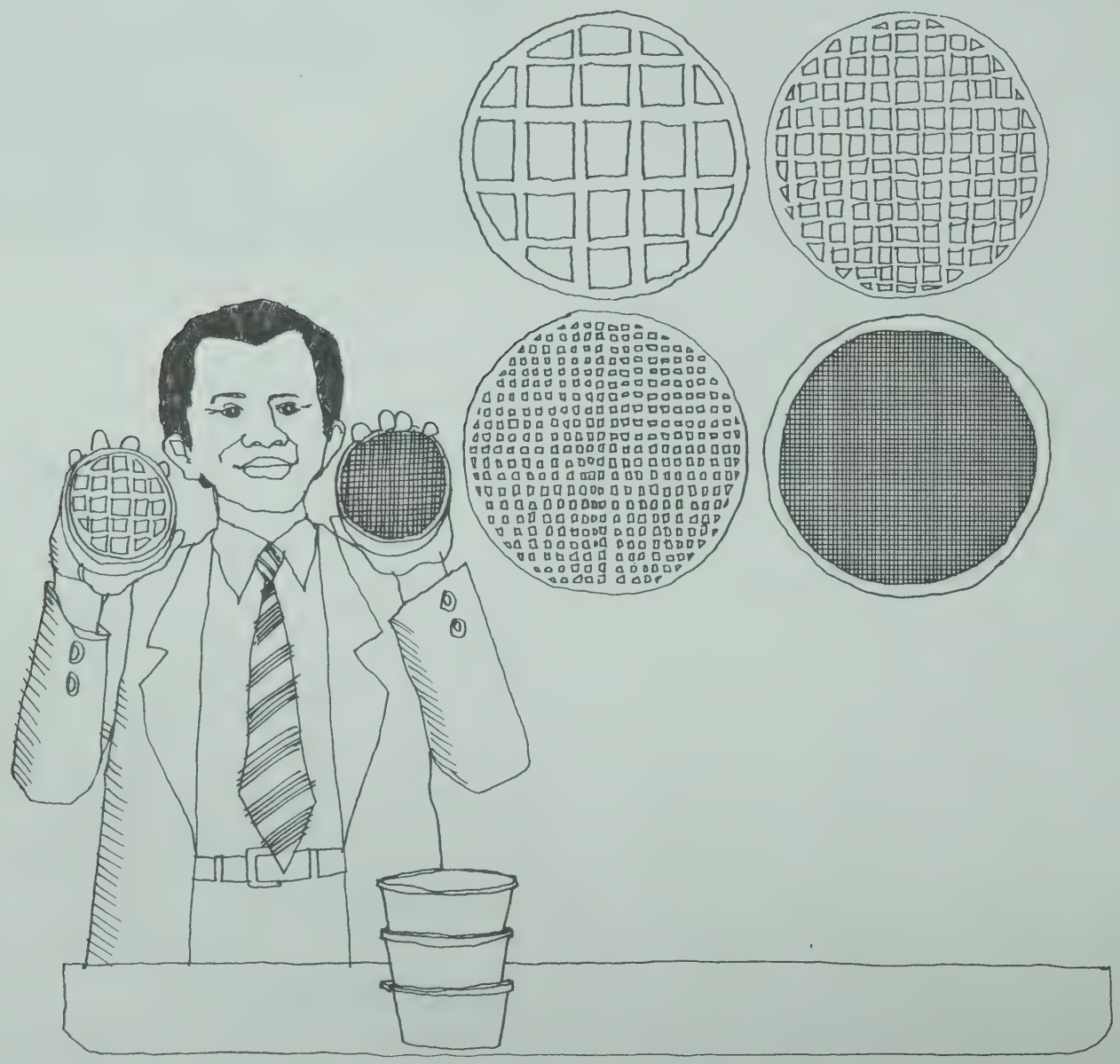

FIGURE 6

Distribute to each *Group A* team a set of nesting sieves, a graduated cylinder, and a mixture of coarse gravel, pea gravel, coarse sand, and dry clay. Give each *Group B* team a graded-screen trough, a graduated cylinder, and a mixture of pea gravel, coarse sand, and fine sand. Have available for the *Group A* teams a 1-liter beaker to measure the volume of the total mixture and of the coarse gravel. The beaker is used because the coarse gravel will not easily fit into the 50-milliliter graduated cylinder. Place the equal-arm balance on a table for both groups to use. Children may use washers or paper clips as arbitrary units of weight. Finally, distribute to the children of both groups a copy of the chart *Classifying Components* on which to record their measurements.

Explain to both *Group A* and *B* teams that you want them to first record the volume and weight of their mixtures and then to separate, measure, and record the volume and weight of the various components of the mixtures. They should record their measurements on the chart you distributed. At this time, draw the children's attention to the charts and help each group fill in the necessary information. *Group B's* chart will look like Figure 3, while *Group A's* chart will contain slightly different information. (See Figure 7.) After separating the mixtures and making the necessary measurements, have each group arrange the components of the mixture by size of particles, by volume, and by weight of material. If necessary, show the children where to record this information on their charts.

Group B teams can begin without any additional assistance because the graded-screen trough was demonstrated previously in *Activity 2.* Have the *Group A* teams discuss methods for making the separation and then have them use one method that everyone in the group thinks is suitable. Some children may see, by trial, that if they pile up the sieves so the solid container is on the bottom and the one with the largest openings is on the top, they can separate the mixture by pouring it in the top sieve and then gently shaking the pile of sieves. (See Figure 8.) Caution the

Classifying Components

MATERIAL	VOLUME, in milliliters	WEIGHT, in _____
1. mixture		
2. coarse gravel		
3. pea gravel		
4. coarse sand		
5. dry clay		
6. sum of 2,3,4,5		

1. Order of components by size of particles:

2. Order of components by volume:

3. Order of components by weight:

FIGURE 7

FIGURE 8

children against pouring the mixture too quickly and shaking the sieves too vigorously. The clay particles are very small and will float for a time as dust in the air if they are agitated too much.

When a particular team has completed their measurements, discuss their findings with them. Children may find that the sum of the volumes of the various components will exceed the volume of the mixture because in the mixture the small particles fit among the large ones. Have the teams of each group discuss their findings.

On another day, you may wish to have the two groups exchange materials so that each group will have a chance to use both sets of materials. Then, in a final concluding discussion, the two groups might compare their measurements.

Materials

Expanding trough, 1 (*Module 42*)
Graded-screen sieves, 4 sets, nesting (*Module 42*)
Containers, 4, 500-ml plastic (*Module 42*)
Gravel, 1 bag, coarse (*Module 42*)
Gravel, 1 bag, pea (*Module 42*)
Sand, 1 bag, coarse (*Module 39*)
Sand, 1 bag, fine (*Module 42*)
Clay, 1 bag, dry, fine (*Module 42*)
Equal-arm balance, 1 (*Module 42*)
Washers, 50 (*Module 37*), or paper clips
Graded-screen troughs, 4 (*Module 42*)
Graduated cylinders, 2, 50-ml (*Module 39*)
Paper, several sheets
Beaker, 1, 1-liter (*Module 42*)
Classifying Components, 1 spirit master, Figure 7 (*Module 42*)

Generalizing Experience

In many industries, mixtures are separated by techniques similar to, though more sophisticated than, the methods the children have used in this module. Sand and gravel of various sizes are separated with graded screens. A field trip to a sand and gravel company would be an interesting extension of this module. Other industries that use similar separation techniques include flour mills and canning plants.

Some children may enjoy making their own "classifying machines." For example, by driving nails partway into a board the children might construct a device to sort marbles or pebbles by size. (See Figure 9.)

Everyone may enjoy making up stories about ways of separating things. For example, the children might consider separating a "mixture" of animals of various sizes by using sets of vertical bars with different spacing. Ask how horizontal bars, or ditches and moats of different widths, could be used instead of the vertical bars.

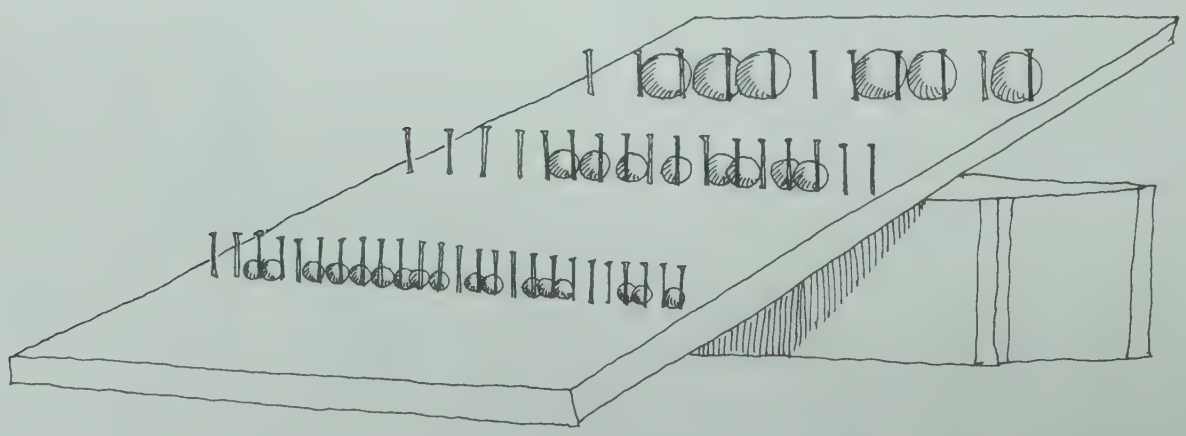

FIGURE 9

APPRAISAL

Give a group of three or four children a mixture of dried lima beans, dried peas, dried mung beans, and salt. Ask the children to separate each of the components from the mixture, using graded-screen sieves.

When the various components are separated, ask all the children to order the components according to the size of the particles. You might ask different individuals to point out the component with the largest particles, the next largest, and so on, until all the particles have been ordered in a series according to their size.

Designate a different group of three or four children to weigh each component with the equal-arm balance. They can use washers or paper clips, or a combination of both, as arbitrary units of weight. On the board, record each component's weight in these arbitrary units. When all the components are weighed, ask all the children to order the weights from the heaviest to the lightest.

Ask another group of three or four children to measure the volume of each component. Record these measurements on the board. Again have the children order the components by volume.

Materials

Dried lima beans, 1 bag (*Module 42*)
(Note: The dried lima beans should be large enough so that they will not go through the sieve with the largest holes. If lima beans are not available, substitute unshelled almonds or walnuts.
Dried mung beans, 1 bag (*Module 42*)
(Note: The mung beans should be large enough so that they will not go through the sieve with the next to smallest holes.)
Dried peas, 1 bag (*Module 42*)
(Note: The peas should be large enough so that they will not go through the sieve with the next to largest holes.)
Salt, 1 bag (*Module 41*)
Graded-screen sieves, 1 set, nesting (*Module 42*)
Equal-arm balance, 1 (*Module 42*)
Washers, 50 (*Module 37*), or paper clips
Beaker, 1, 1-liter (*Module 42*)

COMPETENCY MEASURE

Give the child a mixture of four table-tennis balls, ten or more mothballs, 10 grams or so of pearl tapioca, and a few grams of salt. Put the three separating devices (the two different troughs and the set of sieves) and four sheets of paper on a table in front of the child.

TASK 1 (Objective 1): Say, Separate this mixture into its component parts by any means you wish and tell me how many components there are. The child should separate the mixture into four distinct components using one of the separating devices.

TASK 2 (Objective 2): Say, Order the components you have separated from the mixture according to the size of the particles in each component. The child should arrange the components in the correct order.

TASK 3 (Objective 3): Give the child a 50-milliliter graduated cylinder, an equal-arm balance, and washers or paper clips. Say, Order the components of the mixture according to their volumes or their weights. The child should make the necessary measurements of volume or weight and then order the components in accordance with the measurements.

Materials

Balls, 4 table-tennis
Mothballs, 10 or more
(CAUTION: Warn children not to put the mothballs in their mouths and to wash their hands after using the mothballs.)
Pearl tapioca, 10 grams
Salt, several grams
Expanding trough, 1 (*Module 42*)
Containers, 4, 500-ml, plastic (*Module 42*)
Graded-screen trough, 1 (*Module 42*)
Paper, 4 sheets per child
Graded-screen sieves, 1 set, nesting (*Module 42*)
Graduated cylinder, 50 ml, 1
Equal-arm balance, 1
Washers, 50 (*Module 37*), or paper clips

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MODULE

43

Communicating/e

A Plant Part That Grows

OBJECTIVES

At the end of this module the child should be able to

1. *DESCRIBE* vegetative growth qualitatively.
2. *DESCRIBE* the techniques used to produce growth from plant parts other than seeds, in terms precise enough that other people will be able to follow the procedure.

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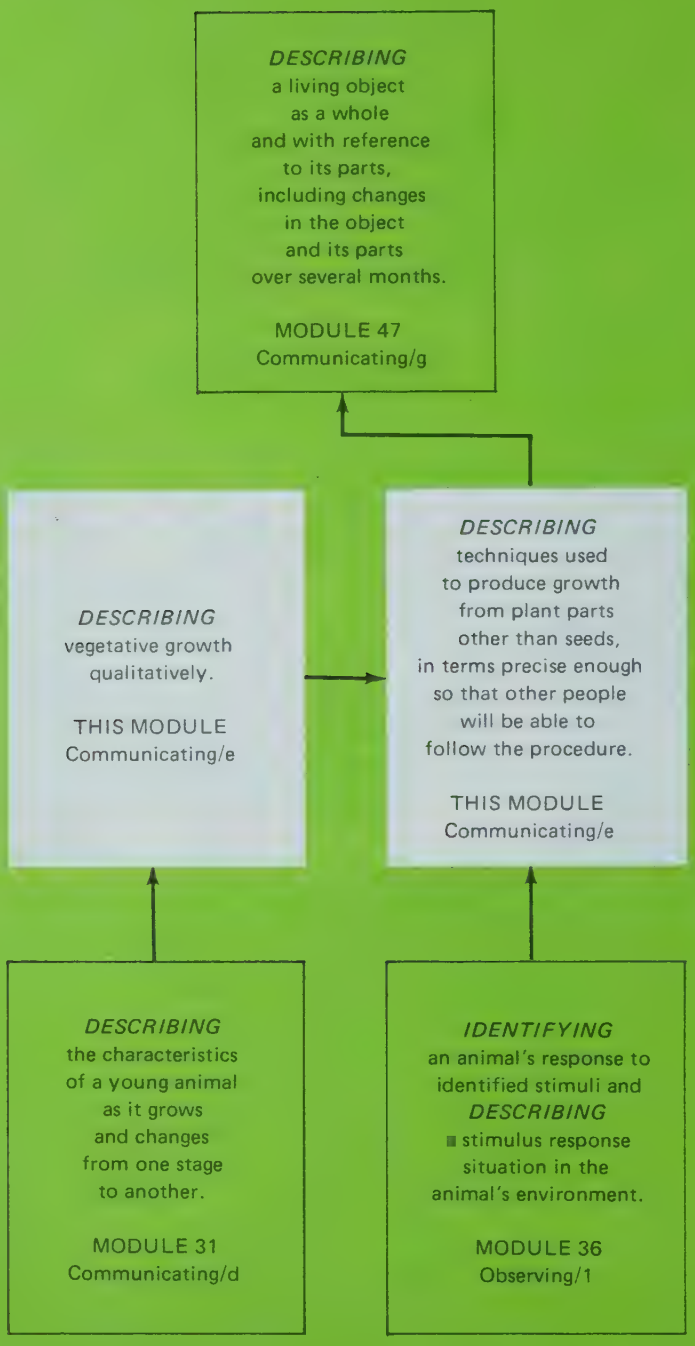
SEQUENCE



Use of this chart, the instruction booklet, and other elements of Science . . . **A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

Plants have two forms of reproduction. The most common and obvious is the sexual form, which results in seed production. The children have studied growth from seeds in previous modules (*Soils, Observing i, Module 19,* and *Molds and Green Plants, Observing k, Module 28*). In the present module, the children have the opportunity to observe that some plants reproduce by means other than seeds. The children work with, observe, and report on asexual reproduction, which may also be called *vegetative growth.* At this level, the children probably cannot state sophisticated definitions of *sexual* and *asexual,* but they should be able to state that some plants do not require seeds for reproduction.

Many of the children will have observed, and can report on, an example of vegetative reproduction at school or home. They may have seen a sweet potato vine growing from a potato; they may have seen someone start a "new" philodendron, geranium, or coleus plant from a stem, or start a white potato from a piece of a potato that contained an "eye." Sugar cane, grapes, and a great many ornamental plants and shrubs are also propagated by vegetative reproduction.

Children learn in this module that only certain parts of particular plants can be used to grow a new plant. The degree to which root, stem, or leaf cuttings develop into mature plants varies with the type of plant. Many plants cannot be started vegetatively.

The children's ability to communicate depends partly upon their ability to observe precisely. This module helps the children develop skills in organizing and reporting their observations. In *Activity 2,* the children play a game called *One Way—Two Way,* in which oral communication techniques are practiced. During this module, each child should have at least one opportunity to give a prepared oral report; *Activity 3,* optional *Activity 5,* and the *Generalizing Experience* all provide such opportunities.

It is recommended that this module be taught sometime after the first of January. During the periods of time required for plant growth throughout the module, you may wish to proceed with one or two other modules.

After *Activity 2,* the remaining activities may proceed in any order.

Vocabulary

cutting	vegetative growth
leaf joint	potato eyes
root	

Advance Preparation

Optional *Activity 5* requires several potted coleus cuttings, which the children use to observe and record stem growth. Take several coleus cuttings such that each has at least four leaves, including the top pair of leaves recently formed. Place the cuttings, cut-edges down, in a container or containers of water or damp vermiculite. Allow about two weeks for the roots to develop. Plant the cuttings in separate flower pots just prior to *Activity 5.*

A rooted African violet leaf is required for the *Appraisal.* With a sharp knife cut a leaf from an African violet plant and put the cut end in water to a depth of a few centimeters. Allow a few weeks for the roots to develop.

INSTRUCTIONAL PROCEDURE

Introduction

Ask the children to help you make cuttings of each of the six plants as described below.

Philodendron and geranium: For each plant, make a cutting that includes at least one leaf and a small section of stem (see Figure 1). Make the cutting below a leaf joint. Put the stem, cut end down, in a 120-milliliter plastic container that has been filled with water. When the cutting develops roots, you might wish to place it in a pot filled with soil.

Other plants that grow quickly from cuttings include ivy, impatiens, wandering Jew, hibiscus, coleus, and some kinds of begonia.

Carrot: Put water in an aluminum pie pan to a depth of about 2 centimeters. Cut away all but 1 centimeter of the leaves from the carrot. Cut through the carrot 4 or 5 centimeters from the top. Put the carrot top in the water

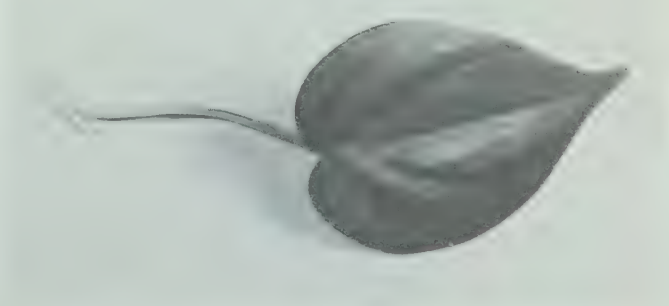

FIGURE 1

with the cut surface on the bottom of the container. Place the cutting in strong light.

Onion: Select a large onion and mount it in a 250-milliliter container with toothpicks as shown in Figure 2. Add water to immerse 1 or 2 centimeters of the onion. Place the onion in a dark or shady place until leaves appear.

White potato: Put a whole potato in a 250-millimeter container filled with water to a depth of 2 centimeters.

Sweet potato: Select a sweet potato. Using a 250-millimeter container, repeat the procedure given for the onion.

If some children wish to bring cuttings from home, encourage them to do so. As soon as the cuttings have been prepared, set them where they will be out of the way. Except where otherwise noted, the plants need not be in direct sunlight until roots are formed. If the plants are where the children can observe them everyday, fine, but this is not necessary.

Proceed with other modules for three to four weeks while the plants grow. Then display the plants on a table and review with the children how each plant was started vegetatively, that is without seeds.

Materials

Philodendron, 1 cutting
Geranium, 1 cutting
Carrot, 1, with leafy top
Onion, 1, large
White Potato, 1
Sweet potato, 1
Knife, 1, to make cuttings
Containers, 2, 120-ml, plastic (*Module 41*)
Containers, 3, 250-ml, plastic (*Module 39*)
Flower pots, 2, small, to plant the leafy cuttings after they have rooted (optional)
Pie pan, 1, aluminum (*Module 43*)
Potting Soil
Vermiculite, 1 bag (*Module 43*)
Toothpicks, 1 box (*Module 43*)

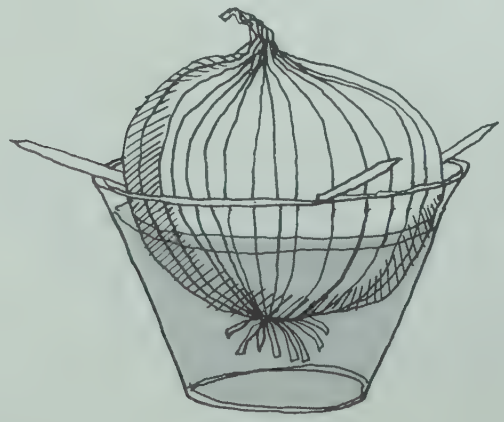

FIGURE 2

Activity 1

Divide the children into groups of five and give each group one of the plants started in the *Introduction.*

Ask each group to find as many ways as possible, aside from the planting of seeds, to start a new plant like the one they have. Explain that each group will select a method to start new plants and then describe the method to the other children. Ask for suggestions about how to find ways to start a new plant. The children may suggest looking in books, asking parents, visiting greenhouses, trying various methods, and so on. Accept their ideas without evaluating them.

This activity will extend over a period of two to three weeks while the children search for information and try their ideas. During this time, continue to encourage the children and remind them to keep records of amounts of water used, how a cutting originally looked, and the procedures followed. Make suggestions for organizing the information so that it can be communicated to the other groups of children. (Oral reports will be given among groups in *Activity 3*). In other words, keep the children's attention focused on the task and, at the same time, ensure their freedom to explore for answers.

Materials

Rooted plant cuttings, 6, from *Introduction*
Reference books, on vegetative growth (optional)
Knives, 6, for making cuttings, or 1 for teacher
Graduated cylinders, 6, 50-ml, for measuring amounts of water used in watering plants (*Module 39*)
Containers, 3, 120-ml, plastic (*Module 41*) and similar containers
Toothpicks, 1 box (*Module 43*)
Flower pots, 3 for each group (*Module 43*)
Potting soil
Vermiculite, 1 bag (*Module 43*)
Writing paper, several sheets for each child
Pencils, 1 for each child

Activity 2

While children are awaiting results from some of their ventures in *Activity 1,* introduce them to the following communications technique, a game called *One Way—Two Way.* One child is selected to be "It" and is given a copy of Figure 3. Do not allow the other children to see the diagram. Give each of the other children a blank sheet of paper and a pencil.

To play the game, "It" turns his or her back to the children and describes the shapes in Figure 3 so that the children can reproduce each shape accurately in terms of size and placement relative to the other shapes. The children may ask "It" no questions, nor may they indicate in any way whether they understand or are finished.

Record on the chalkboard the time from the moment "It" begins the description until he or she stops. Ask how many children are confident that their diagrams are accurate. Record this number below the time. "It" now reveals the diagram to the children. Ask how many children drew the diagram accurately. Record this number.

Now give "It" a copy of Figure 4. Again, do not allow the other children to see the diagram. Ask the children to turn their papers over. This time, "It" faces the children to describe the diagram, the children may ask questions, and "It" may respond freely to all questions. Again, record the time and ask how many children are confident that their diagrams are accurate. Record that number. "It" then shows the diagram and asks how many children drew the diagram accurately. Record this number.

Discuss with the children the game they have just played, emphasizing the following points:

1. The first description was an example of "one-way" communication; the second description was an example of "two-way" communication.
2. "One-way" communication is difficult because the speaker has no feedback as to whether or not he or she is being understood.
3. "Two-way" communication results in greater accuracy, and usually takes less time to achieve this accuracy.
4. In both kinds of communication, precise language results in greater understanding and accuracy.

Ask each child to make two new diagrams. Divide the children into groups of five for playing the game. This time each child should have a chance to be "It" and to describe the two diagrams to the group. After the children are familiar with the game, encourage them to describe a plant instead of a diagram. This will be more difficult for both "It" to describe and for the other children to draw, so have them continue this only if interest is high.

Materials

Drawing paper, 4 or 5 sheets for each child
Pencils, 1 for each child

Activity 3

Pair the groups formed in *Activity 1;* for example, put the philodendron and the onion groups together. Tell each group to present to its partner group a prepared oral report that describes one way to start a new plant. The reports should be carefully detailed and based on the investigations performed by the groups in *Activity 1.* Explain that after each group has described a method for starting a new plant, each "listening" group will follow that method to start a new plant of the same variety.

Emphasize again that communication is a two-way process. Members of the "listening" group may need to ask questions of the "describers." This questioning provides feedback, which helps the development of more precise descriptions.

Materials

Plant cuttings, fresh ones like those in *Activity 1*
Containers, 3, 120-ml, plastic (*Module 41*) and similar containers
Knives, 6, for making cuttings, or 1 for teacher
Toothpicks, 1 box (*Module 43*)
Graduated cylinders, 6, 50-ml, for measuring amounts of water used in watering plants (*Module 39*)
Potting soil
Vermiculite, 1 bag (*Module 43*)
Flower pots, 2 for each group (*Module 43*)
Writing paper, several sheets for each child
Pencils, 1 for each child

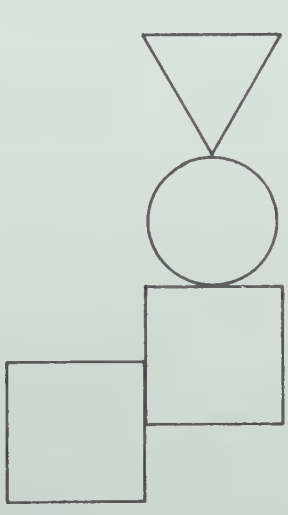

FIGURE 3

FIGURE 4

Activity 4 (Optional)

Cut several white potatoes into sections so that some sections contain eyes and some do not. Distribute one potato section to each child. Ask the children to check their potato section for eyes. Give each child a paste stick and a 250-milliliter milk carton filled with vermiculite. Have the children put their names on the paste sticks, record the number of eyes on their potato sections, and write "yes" or "no" depending on whether or not they think the sections will have new growth. Have the children plant the potato sections about six centimeters into the vermiculite, add water, put the paste sticks into the milk cartons, and place the milk cartons in a designated location. Have the children make arrangements to give all the plants the same amount of water each day. It will be necessary to punch small holes in the bottom of the cartons to permit excess water to drain. Place the cartons on the trays provided.

Have the children observe the potato sections and record their observations daily. After evidence of new growth has appeared in several cartons, ask the children to organize their data so they can compare the growth of potato sections with eyes to those without eyes. Ask the children what inferences they can make about what a potato needs to produce new growth. (It needs eyes.)

Materials

White potatoes, several
Knife, 1, sharp, for cutting potatoes
Paste sticks, 1 package (*Module 43*)
Milk cartons, 30, 250-ml, or similar containers
Vermiculite, 1 bag (*Module 43*)
Crayons, several, for marking the paste sticks
Graduated cylinders, several, 50-ml (*Module 39*)
Trays, 5 (*Module 43*)
Writing paper, several sheets for each child
Pencils, 1 for each child

Activity 5 (Optional)

Ask the children if they know where growth takes place on the stem of a leafy cutting. This is a difficult question to answer because plants differ. If some children are curious, ask, for example, "Where does growth take place on the stem of a coleus cutting?" Suggest that the interested children try to find an answer to this question.

Provide several potted coleus cuttings (see *Advance Preparation*). Help the children use a felt-tip pen to mark off in segments of equal length along the stem between the top two pairs of leaves on each cutting. (See Figure 5.) Suggest a location for the plants that will provide good light.

Have the children observe the growth of the plant by measuring and recording the growth of each segment every two days. Also have them graph the information on a grid such as that shown in Figure 6 each time the segments are measured. After about two weeks of observation by the children, suggest that they present their findings to the rest of the class. Be sure the discussion that follows is "two-way" communication.

Materials

Potted coleus plants, several, with 4 leaves on each, including the top two leaves recently formed
(Note: Prepare these plants from cuttings as described in *Advance Preparation*.)
Felt-tip pen, 1, for marking off stems
Metric ruler, 1 (*Module 34*)
Writing paper, 1 sheet for each child
Pencils, 1 for each child
Graph Paper, 1 spirit master (*Module 43*)

Generalizing Experience

Suggest that the children find out whether other kinds of plants of their choosing can produce new plants vegetatively, that is, without seeds. Groups of two or three children might try to grow kinds of plants different from those they have already studied. For example, they might try a pineapple top instead of a carrot top, a turnip instead of a sweet potato, and so on. Let the children use whatever plants and parts of plants they suggest and can bring from home.

During these investigations, continue to encourage the children to observe carefully and to record what they did, what they observed, and what they concluded. Have the children report their findings to the class in an organized way. When appropriate, help them to generalize from their observations.

Materials

A variety of plants and plant parts, from which to make cuttings
Containers, 10-15, 120-ml, plastic (*Module 41*)
Knives, 6 for making cuttings, or 1 for teacher
Toothpicks, 1 box (*Module 43*)
Graduated cylinders, 6, 50-ml (*Module 39*)
Potting soil
Vermiculite, 1 bag (*Module 43*)
Flower pots, 10 to 15 (*Module 43*)
Writing paper, several sheets for each child
Pencils, 1 for each child

APPRAISAL

Show the children an African violet plant, and ask them to describe it. Then tell them that you are about to do something that they should watch carefully. Tell them that when you are finished, you will ask someone to report in detail what you did and what you might be trying to find out.

Cut one of the leaves from the African violet plant, and follow the procedure outlined in *Advance Preparation* for rooting a leaf. Label a paste stick with the date and insert it into the container. Ask several children to describe what you did. Encourage other children to question the described procedure so that the description is clear and precise.

Now put in front of the children a previously prepared African violet leaf that has developed roots. Tell the children that you put this cutting in water a few weeks before. Ask various children to infer what will happen to the newly-cut leaf.

Materials

African violet plant, 1, potted
Knife, 1
Container, 1, 250-ml, plastic, filled with water (*Module 39*)
Paste stick, 1
African violet leaf, 1, previously rooted (see *Advance Preparation*)

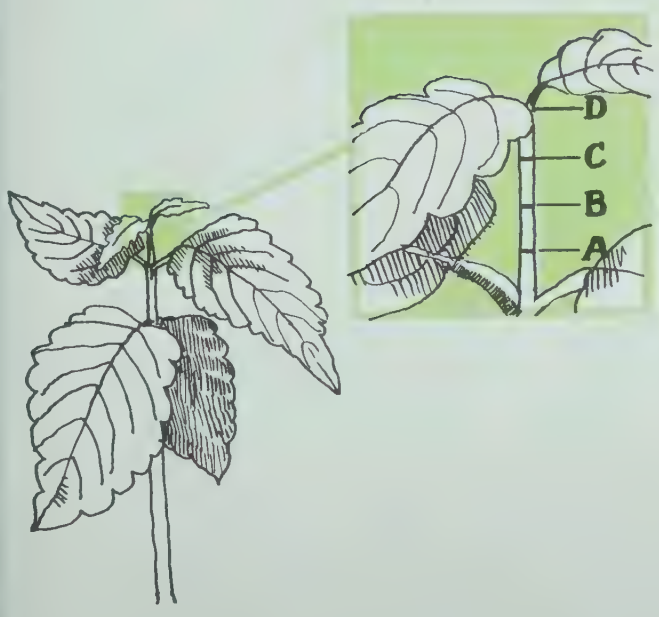

FIGURE 5

COMPETENCY MEASURE

Show the child the picture card of a strawberry plant, showing roots, leaves, and a runner with leaves and small roots.

TASK 1 (Objective 1): Ask, How is new growth occurring in this plant? The child should indicate observation of the runner with three leaves and that a new plant might be developing this way.

TASK 2 (Objective 1): Say, Show me where new growth might appear next. The child should point to the three leaves at the end of the runner.

TASK 3 (Objective 2): Show the child a begonia plant, and say, Describe how you might start a new plant from this one without using seeds. The child's description should include the following steps, in the order listed:

1. Cut below a leaf joint so that the cutting includes a piece of the stem and one or more leaves.
2. Put the cutting into a container of water.
3. When roots have developed on the cutting, plant it in soil and/or vermiculite.

Materials

Strawberry Plant, 1 picture card (*Module 43*)
Begonia plant, 1

(Note: If a begonia plant is not available, provide a similar plant, new to the children, from which cuttings might easily be taken.)

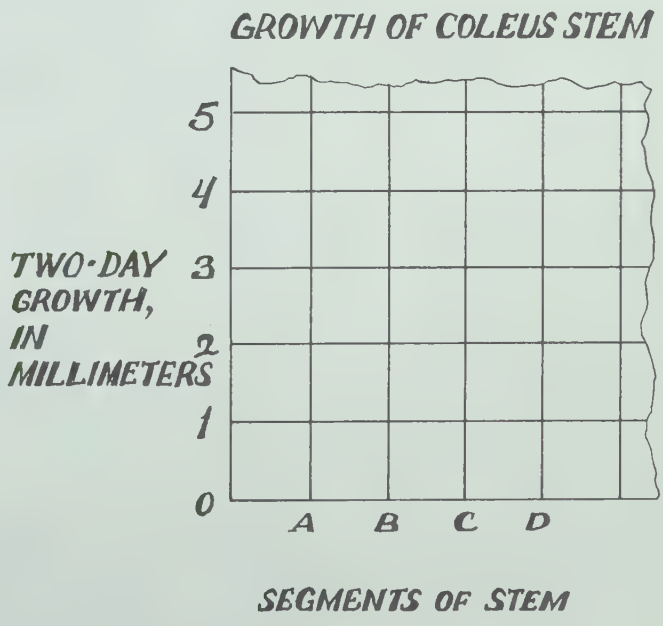

FIGURE 6

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MODULE

44

Predicting/b

Surveying Opinion

OBJECTIVES

At the end of this module the child should be able to

1. *DESCRIBE* a method for collecting and organizing simple data.
2. *CONSTRUCT* a bar graph to represent a given collection of data.
3. *CONSTRUCT* a prediction based on an examination of the data presented in a graph or collection of graphs.

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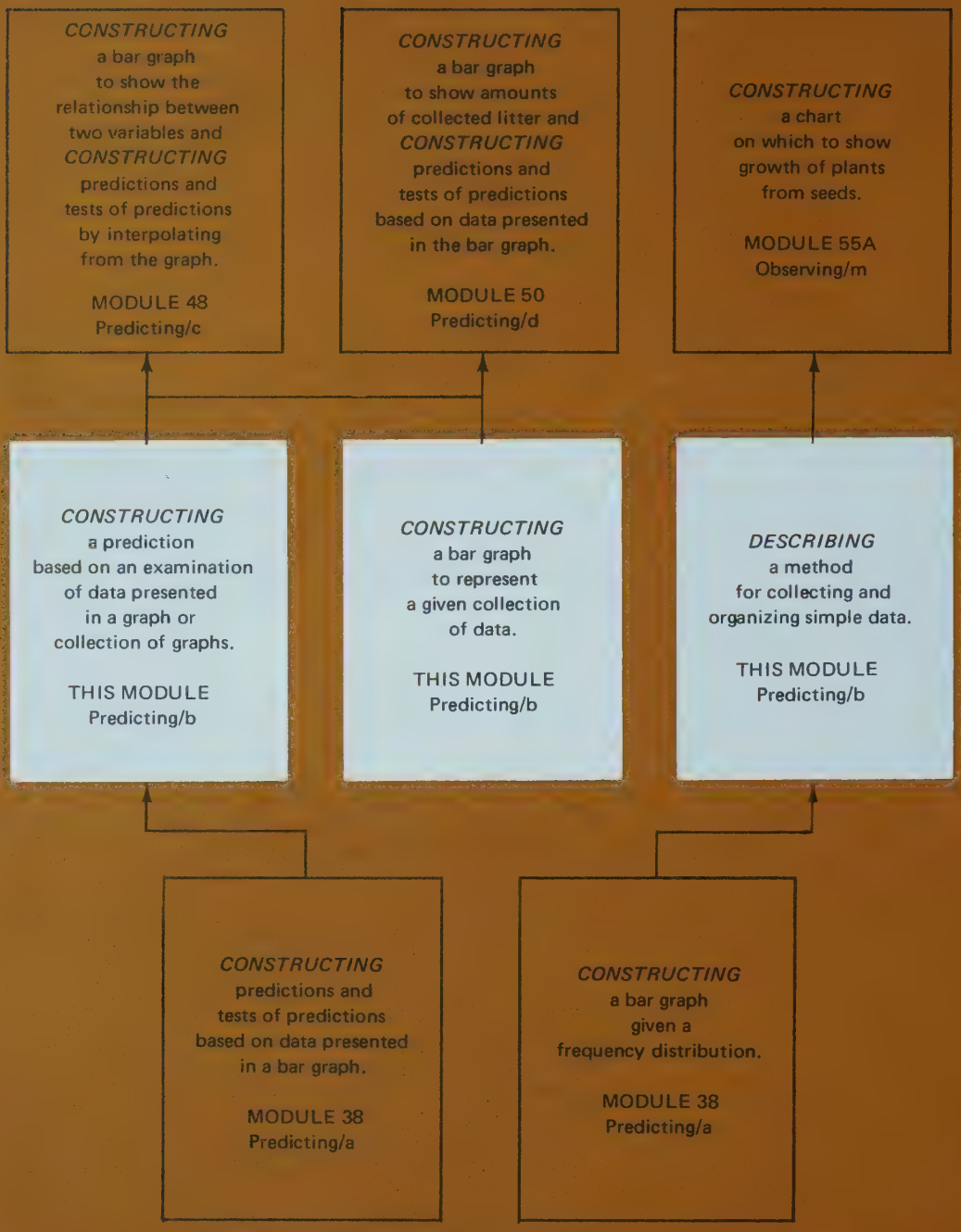
SEQUENCE


CONSTRUCTING a bar graph to show the relationship between two variables and *CONSTRUCTING* predictions and tests of predictions by interpolating from the graph.
MODULE 48 Predicting/c
CONSTRUCTING a bar graph to show amounts of collected litter and *CONSTRUCTING* predictions and tests of predictions based on data presented in the bar graph.
MODULE 50 Predicting/d
CONSTRUCTING a chart on which to show growth of plants from seeds.
MODULE 55A Observing/m
CONSTRUCTING a prediction based on an examination of data presented in a graph or collection of graphs.
THIS MODULE Predicting/b
CONSTRUCTING a bar graph to represent a given collection of data.
THIS MODULE Predicting/b
DESCRIBING a method for collecting and organizing simple data.
THIS MODULE Predicting/b
CONSTRUCTING predictions and tests of predictions based on data presented in a bar graph.
MODULE 38 Predicting/a
CONSTRUCTING a bar graph given a frequency distribution.
MODULE 38 Predicting/a

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

It is essential that contributing evidence upon which a prediction is based be collected, organized, and recorded in a clear and usable way. The activities in this module provide children with experience in making predictions based on data recorded in a survey of children in the school, thus using the children's natural interest in collecting, interviewing, and surveying.

You must be sure to point out carefully the limitations on the dependability of predictions based on an opinion survey. Emphasize that accurate predictions are difficult in the early phases of the survey, and are impossible if they are based on only small bits of information. As more data are added, trends or patterns are often noticeable. These trends can be used to make more reliable predictions. The procedures introduced in this module are complex; they include the sampling of opinions and the ways by which reliable samples of a population are chosen and analyzed. This module introduces these procedures in only an elementary way and for the sampling of only small populations. For these reasons, the data may vary widely, or it may be deceptively homogeneous.

Because favorite kinds of snacks are the subject matter of this module, the results of the surveys are unpredictable and may vary considerably with locale, time of year, the children's previous experience, and other factors. Remember that although the children will be very much interested in the results of the survey, these results are merely a means to an end. The objective is to provide experience in making predictions based on available evidence.

Those who have used this module report a beneficial carry-over into health studies. After engaging in these activities, some children became more careful about their snacks. An incidental difficulty arose in spelling the various snacks. Assist the children with troublesome words so that spelling difficulties will not dampen their enthusiasm.

In *Activity 3,* the children survey other groups in the school. Take advantage of the excitement that such surveys create and the opportunity they provide for improvement of communication skills, but be sure to plan the surveying procedures carefully with the other teachers involved. The surveys could involve not only those children following the same sequence of modules that your own children are following, but also children using *Science . . . A Process Approach* in other modular sequences.

Vocabulary

predict	tally
prediction	poll
survey	polling
opinion	

INSTRUCTIONAL PROCEDURE

Introduction

Ask the children what the word *predict* means to them. They may have several suggestions. For example, they may recall that when they studied *Shadows, Using Space/Time Relationships e, Module 29,* they were asked to predict the two-dimensional shapes of the shadows of a three-dimensional object. After they made their predictions, they put the objects in the shadow box and turned on the lights to see what the shadows were. In that module, they were testing their predictions. Ask the children if their predictions were just guesses. Discussion should include the idea that because the children had previously tried a number of objects in the shadow box and had observed the shadows of those objects, they had a basis in experience for saying beforehand what the result would be.

The children should also recall the predictions they made from the bar graphs they constructed in *Using Graphs, Predicting a, Module 38.*

Perhaps some child will mention that the weather man predicts the weather. Another may recall a time of national elections when there were predictions about which candidate would win. Remind them that predicting is telling what you think is going to happen based on experience.

If possible, bring periodical or newspaper examples of polls that have been taken. A copy of a survey made within the school would be useful too. Discuss the value of surveys. Use questions as these:

What is an opinion?

What is a survey?

How is the information obtained when we survey opinion?

Suggest that the class make its own survey. Ask whether a survey about favorite kinds of snacks would be interesting. Other topics, such as favorite animals or favorite television programs, could also be used.

Materials

Surveys, several examples from periodicals or newspapers (optional)

Activity 1

Give each child a piece of paper and a pencil. With no preliminary discussion ask the children to write down the names of three of their favorite kinds of snacks. Be sure that they do this independently. Then collect their papers.

Tell the children that you have just taken a *poll* of their favorite snacks. Ask which snack the children think was named the most times. After several children have expressed their ideas, ask why they think a particular snack was the most popular. Suggest that their ideas are largely guesses because, at this point, they have little or no evidence to use as a basis for making predictions. If necessary, also explain that by examining all the papers, they could find out which kind of snack the class members chose the most times. Tell the children that they will soon have the opportunity to do this. Ask them to think of ways that this could be done so that each child can participate and also have a copy of the results.

Materials

Writing paper, 1 sheet for each child
Pencils, 1 for each child

Activity 2

Ask the children for their ideas about organizing the data so that each child can have a copy of the results. There should be a number of suggestions. Try to accept one of them.

If the children do not suggest a feasible plan, use the following procedure. Give each child one paper marked during the previous activity, a clean sheet of paper, and a pencil. Call on the children to read from their marked papers. When a snack is first mentioned, tell everyone to write it down and put a tally mark next to it; each time it is mentioned again, have everyone put another mark next to the snack. Several children will probably have listed specific candy bars, flavors of ice cream, and so forth. Have the children tally all such listings under general headings, such as "candy" and "ice cream." Some children may list two items such as "cookies and milk." In this case put one tally next to "cookies" and another next to "milk."

The final tally will show the total number of times each snack has been mentioned. After all of the children have read their papers to the group, have one child read aloud his or her final totals so that the children can check their own records of totals for each snack.

For the purpose of discussion, ask the children to imagine that milk was named more often than any other kind of snack, and that it was listed 20 times. Also ask them to imagine that candy was named 6 times and ice cream was mentioned 4 times. Figure 1 shows how these data may be graphed.

Project the transparency *Graph Paper* on the overhead projector, cover the transparency with the overlay, and construct Figure 1 for the children. Ask the children if they can identify each entry that you make on the graph; that is, the vertical number line, the horizontal base line, the vertical label, the horizontal label, the graph title, and the bars that record the data for each snack.

Give each child a sheet of graph paper, and have the children make graphs of their tallies, using as a model the graph that you showed them with the overhead projector.

Materials

Writing paper, 1 sheet for each child
Pencils, 1 for each child
Transparency, 1, duplication of *Graph Paper* (*Module 38*)
Overlay for transparency, 1 (*Module 44*)
Transparency marker, 1
Graph Paper, 1 spirit master (*Module 44*)

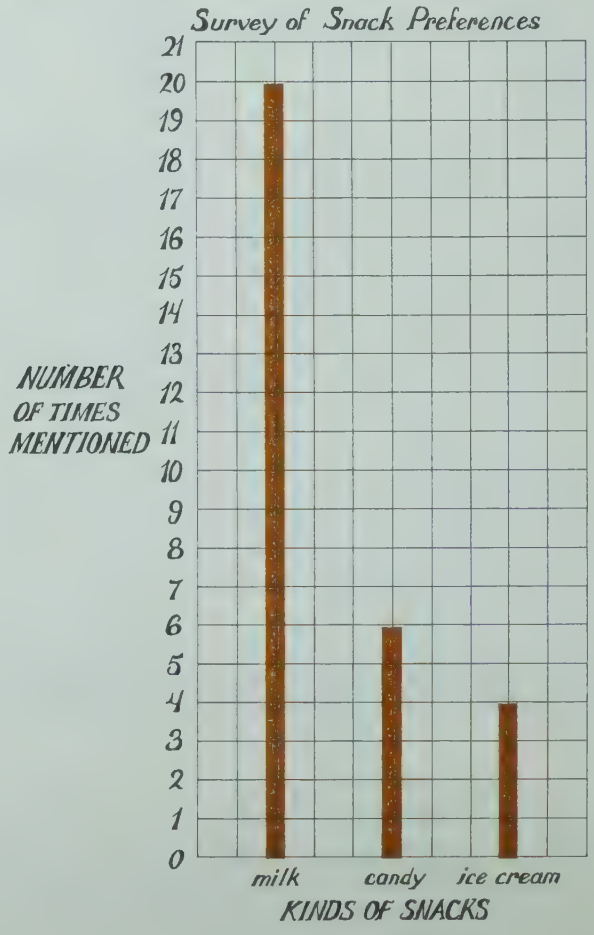

FIGURE 1

Activity 3

Ask the children how they think their survey about snacks would compare with similar surveys of children in other rooms. Discuss the reasons for their opinions.

Ask the children the following kinds of questions that refer to the data in Figure 1; you will undoubtedly want to substitute the data collected by your children.

Does the fact that 20 out of 30 children chose milk as their favorite snack means that 20 out of another group of 30 children would make the same choice?

Could more (or fewer) than 20 children like milk best?

What would you predict if you had to make a prediction now about how many children in another room would choose milk as their favorite snack? Would you guess 20 out of 30, or close to that?

Do you feel very comfortable with this prediction? (Probably not. The prediction was based on data from only one group.)

Would you like to get data from other classes?

If the children answer "yes" to the preceding question, help them plan ways to survey the opinions of children in other rooms. Organize committees of children to visit the other rooms. The committee members will ask those children to make lists of favorite snacks as they themselves did in *Activity 1.* Of course, you will need to arrange this in advance with the teachers of other groups involved. You might want to use paper of different colors to distinguish among the various rooms surveyed.

Have the children survey the same number of children in each room as were surveyed in your room so that a direct comparison of the data can be made. If different numbers of children are surveyed, the results would have to be converted to percentages, which the children are not yet able to do.

Materials

Writing paper, several sheets for collecting data
Pencils, 1 for each child

Activity 4

Collect the polls for the various rooms and organize the children into groups to tabulate the data for all but one of the rooms. Hold back the data for one room; these data will be used for making predictions.

Ask the children if graphing the data from the other rooms might help them compare these data with their own, previously graphed results. Suggest that they graph the data from one of the other rooms to see how graphs are helpful when making comparisons. Use such questions as the following to help the children remember the kinds of information to include on their graphs.

What information should go on the grid?

Where should we place the title?

What label should we use for the vertical number line?

What label should we use for the horizontal base line?

After you have reviewed the important parts of the graph, have the children graph the data for one of the other rooms. Using the transparency *Graph Paper* on the overhead projector may help the children get started. Discuss the graphs with the children. They should note that a quick examination of the lengths of the bars for each snack does help in making comparisons. If the children do not suggest it, mention that, for making comparisons, there might be some advantage in placing all bars for one snack on the same graph.

Suggest that each child construct such a graph showing the preference for candy, for example, in all rooms. As the children work, you might demonstrate the graphing procedures at the overhead projector. Put numerals from 0 to 20 along the vertical number line and label it "Number of Times Mentioned." (If any of the tallies total higher than 20, have the children number the vertical number line by two's. The vertical number line on the graph paper supplied goes only from 0 to 20 when numbered by one's. (See Figure 2.) Write the names of the teachers of the groups surveyed along the horizontal base line, and label it "Groups Participating in Survey." Write an appropriate title, for example, "Survey of Candy Preferences," at the top of the graph. The title will vary with the snack being compared.

Now, using data from your own room, draw a bar on the graph at the overhead projector. Tell the children to draw the corresponding bar on their own graphs. Next have the children draw bars on their graphs to represent the data from the other rooms, as you place bars of appropriate heights on the graph at the overhead projector. Each bar should be placed on the vertical line representing the room surveyed. (See Figure 2.) Then have the children construct graphs for the other snacks, each on a separate sheet of graph paper.

Now focus attention on one of the graphs that illustrates, for example, candy preferences. Ask the children

if the results for the other rooms are the same as, close to, or very different from the results for their own room. Remind the children about the set of data, for one room, yet to be shown on the graphs. Ask the children to predict on the basis of the collection of graphs, what snack the children in the remaining room would prefer. Have the children lightly mark their predictions on their graphs at the line for that class. Emphasize that the two or more sets of data, now shown on the graphs, may allow the children to state a more valid prediction than they were able to make earlier on the basis of only one set of data. As you and the children consider the array of graphs, ask as many children as possible to explain why they made the predictions they did.

Now have the children tabulate the data from the remaining class and proceed with the graphing and discussion as before. Ask the children how accurate their predictions were.

You may want to ask some of the children to construct a bulletin-board graph showing data from several classes. This graph should be where other children in the school, and their parents, can see it.

Materials

Transparency, 1, duplication of *Graph Paper* (*Module 38*)
Overlays for transparency, 1 for each kind of snack (*Module 44*)
Transparency marker, 1
Graph paper, 1 spirit master (*Module 44*)
Pencils, 1 for each child
Drawing paper, 1 large sheet, for bulletin-board graph (optional)

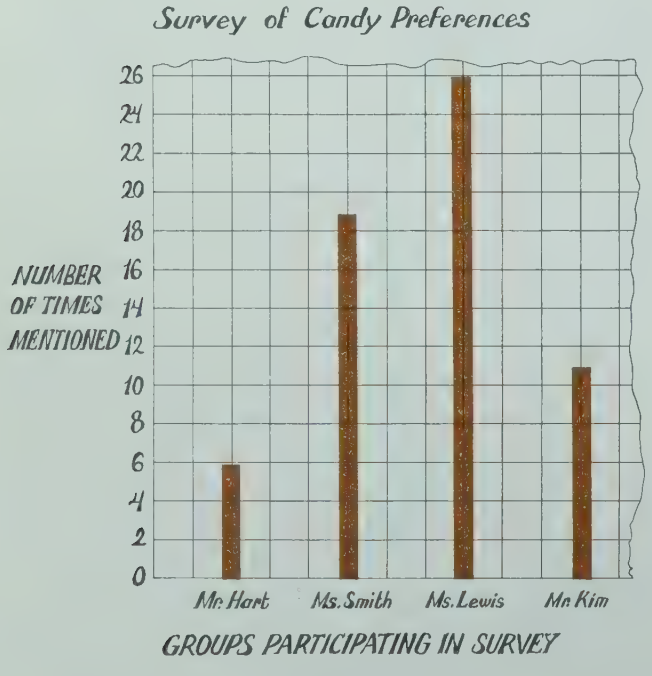

FIGURE 2

Generalizing Experience

Some children may be much more interested in this series of activities than are others. You should provide opportunities for the most interested children to continue with the surveys and to report the tallies to the others in the room. The entire group could then construct the graphs and participate in discussion of the results.

Ask the children to make additional surveys about snack preferences. For example, have them ask a teen-ager, their mother or father, or some other friend to list three favorite kinds of snacks. You will get greater cooperation from the parents if you send a note with the child describing the project and the importance of the information. The children should get data from the same number of adults as there are members in their room. Tell the children that they should make their predictions beforehand and discuss the reasons for them. Then have them make the tabulation and discuss the results. If you find that more practice in graphing is desirable, you could have the children graph these data before they discuss the results.

It may be appropriate in your area to encourage the children to collect, tabulate, and graph data related to their social and physical environment, such as the numbers of rural and urban families represented in the room, the occupations of parents, the types of family recreation, the kinds of trees on the school ground, and the children's distances from school in some designated unit of measure such as the number of blocks. These graphs do not need necessarily to lead to predictions. However, if any predictions are suggested by the data the children have chosen, be sure to give attention to them.

Materials

Writing paper, 1 sheet for each child
Pencils, 1 for each child
Graph paper, 1 spirit master (*Module 44*)

APPRAISAL

Divide the children into two groups, each containing about the same number of boys and girls. Ask everyone to write on a piece of paper the names of their three favorite flavors of ice cream. Have the children in one group tabulate their own data, and ask the other group to do the same. Be sure the groups do not overhear each other's results.

Give each child a sheet of graph paper, and ask the children to record the flavors their own group mentioned. Each graph should have bars for each flavor of ice cream listed.

Now ask the members of each group to indicate on the graph lightly in pencil their prediction about the results they would expect from the other group of children. Appoint one child in each group to direct the others as they construct a graph of their data on a large grid. When the graphs are ready, display them on the bulletin board.

After the children have compared the graphs and observed the success or failure of their predictions, ask several children who made reasonably accurate predictions to tell why and/or how they made them.

Materials

Writing paper, 1 sheet for each child
Pencils, 1 for each child
Graph Paper, 1 spirit master (*Module 44*)

COMPETENCY MEASURE

TASK 1 (Objective 1): Say to the child, **In planning for the school picnic, the P.T.A. members want to get an idea of how many hamburgers, hot dogs, and cold-meat sandwiches to make. Tell me how they could get the information they need.** The child should describe a method of surveying some of the children in the school.

TASK 2 (Objective 2): Say, **A poll in Miss Brown's room of 30 children gave the following data about preferences: hamburgers, 15 children; hot dogs, 10 children; cold-meat sandwiches, 5 children.** Give the child the data on a piece of paper or write the information on the chalkboard. Then give him a piece of graph paper and say, **Make a graph showing the number of times each kind of food was chosen.** The child should include the following entries on the graph: a proper title that identifies the subject of the graph, a scale of numerals on the vertical number line, the name of the teacher whose children were surveyed—perhaps included in the title, the proper labeling of the horizontal base line and vertical number line, bars drawn to the correct height to show the number of choices. If the child makes any errors in constructing the graph, correct them before continuing.

TASK 3 (Objective 3): Ask the child, **Could you use your graph to predict exactly how many times hamburgers would be chosen by the children in another room?** The child should indicate that an exact prediction probably cannot be made.

TASK 4 (Objective 3): Show the child the two picture cards of graphs—one showing a graph that represents the choices made by the children in Mr. Smith's room, the other showing a graph that represents the choices made by the children in Miss Jones' room. Read the labels below the horizontal base line of each graph. Say, **Look at the three graphs—the one you made and the two I have just given you. Make a prediction about which kind of food the children in Mrs. White's class will select most often.** The child should say, "Hamburgers."

TASK 5 (Objective 3): Ask, **Why did you make that selection?** The child should identify a pattern that supports his or her answer.

Materials

Graph paper, 1 spirit master (*Module 44*)
Pencils, 1 for each child
Picture cards, 2, each showing results of a survey for a school picnic (*Module 44*)

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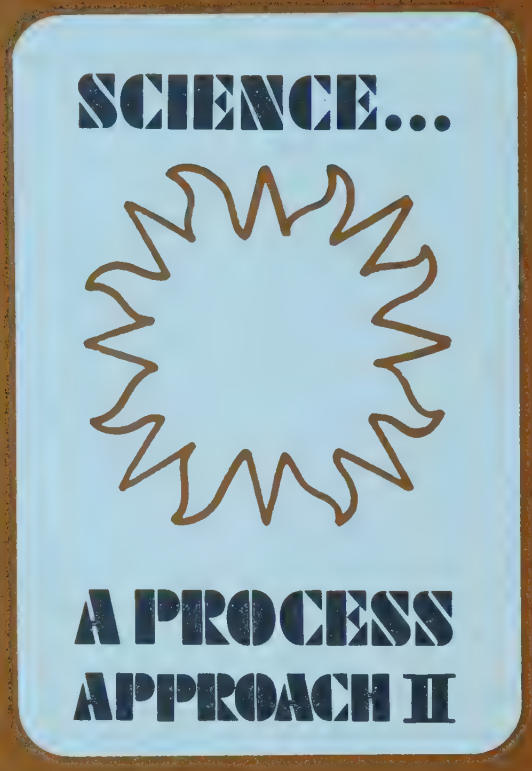
44 Predicting/b



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SCIENCE... A PROCESS APPROACH II

MODULE

45

Using Space/Time Relationships/g

Lines, Curves, and Surfaces

OBJECTIVES

At the end of this module the child should be able to

1. *IDENTIFY* and *NAME* straight and curved paths on a plane surface.
2. *CONSTRUCT* curved paths on the surface of a sphere, a cone, and a cylinder and straight paths on a cone and cylinder.
3. *DEMONSTRATE* how to determine whether a surface is a plane surface.
4. *DISTINGUISH* linear from nonlinear motion.
5. *IDENTIFY* and *NAME* circular motion.

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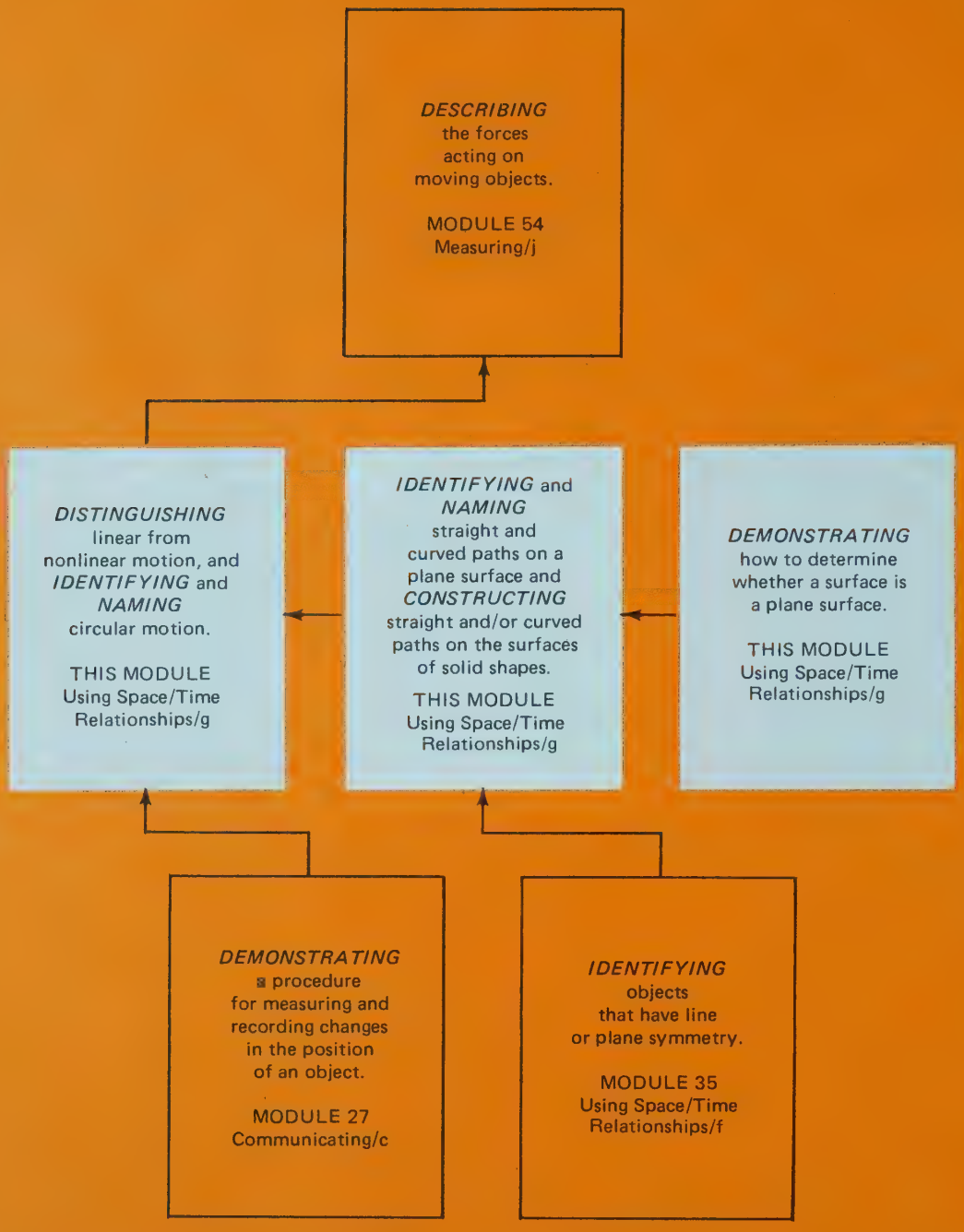
SEQUENCE


DESCRIBING the forces acting on moving objects.
MODULE 54 Measuring/j
DISTINGUISHING linear from nonlinear motion, and *IDENTIFYING* and *NAMING* circular motion.
THIS MODULE Using Space/Time Relationships/g
IDENTIFYING and *NAMING* straight and curved paths on a plane surface and *CONSTRUCTING* straight and/or curved paths on the surfaces of solid shapes.
THIS MODULE Using Space/Time Relationships/g
DEMONSTRATING how to determine whether a surface is a plane surface.
THIS MODULE Using Space/Time Relationships/g
DEMONSTRATING a procedure for measuring and recording changes in the position of an object.
MODULE 27 Communicating/c
IDENTIFYING objects that have line or plane symmetry.
MODULE 35 Using Space/Time Relationships/f

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

This module provides an introduction to motion in linear and nonlinear paths on plane and curved surfaces. In order to better understand motion on particular kinds of paths, the children first study straight lines and curved lines on plane surfaces and on the surfaces of three-dimensional shapes.

In general, throughout the module, terms that already have meaning for the child are used. To illustrate, no distinction is made between a straight line and a line segment; the "lines" observed are simply called "straight line paths" or "straight paths". A curve that returns to the starting point is called a "closed path," and is distinguished from a curve that is not closed. A circle, of course, is a closed path. The idea of a closed path is particularly useful in the study of area.

Two booklets on straight and curved lines and surfaces are provided as auto-instructional instruments in *Activity 1*. As the children complete the tasks in the booklets, they acquire the skills defined in Objectives 1, 2, and 3. Have as many of the children as possible complete the tasks in the first of the two booklets before beginning *Activities 2* and *3*.

Objectives 4 and 5 are concerned with motion. Although the concepts of paths and motion are distinct, every motion implies a path. Both concepts are thus necessarily involved in the activities. This difference need not be emphasized with the children at this time, but clarify the concepts for them if they ask.

One way to classify motion is shown in Figure 1. This scheme is the basis for ordering the activities. *Activity 2* treats linear and nonlinear motion and paths. *Activity 3* and optional *Activity 4* introduce circular and noncircular motion and paths.

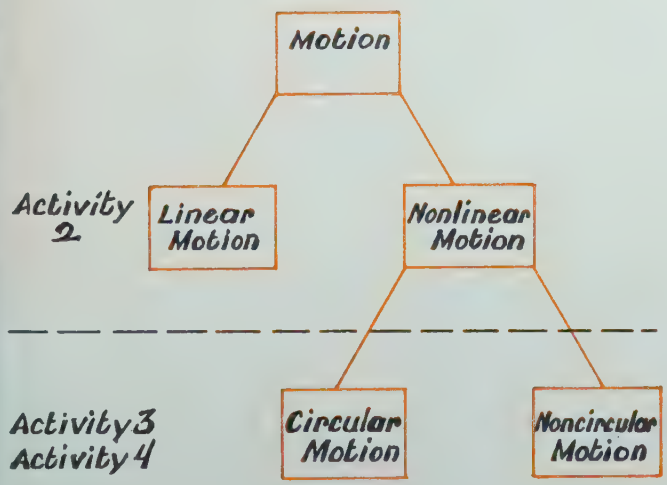

FIGURE 1

Vocabulary

straight line	linear
curved line	nonlinear
closed path	circle
open path	circular
curved surface	noncircular
flat surface	rotate
plane surface	rotation

INSTRUCTIONAL PROCEDURE

Introduction

Ask the children to hold up their hands if they know what a straight line looks like. All or nearly all hands should go up. Then say that you have run into a little problem and need their help. Tell a story about a friend who drew two pictures of railroad tracks. She was not sure when she finished that a train could run on the tracks if they were built in the way she drew them. Show the children the optical illusions in Figures 2 and 3 on the next page. Ask which set of tracks the children think the train will be able to run on. The illusions will make the question difficult to answer. Be noncommittal and let the children discuss the contradiction the illusions produce.

While interest is still high, ask the children how many ways they can think of to test the lines to find out if they are straight. Give each child a copy of *Train Track 1* and *Train Track 2*. Encourage the children to show each other various methods for examining the lines for straightness. One child might sight along the plane of the paper; another might place a straight-edge next to one of the lines. If a child suggests checking the distance between the lines at different places, call everyone's attention to it and ask all the children to do this.

At some time in the course of the following activities, as you refer to paths and motion, begin to use the terminology in the *Vocabulary* list. When the children ask what a new word means, tell them and spell it for them.

Materials

Train Track 1, 1 spirit master, Figure 2 (*Module 45*)
Train Track 2, 1 spirit master, Figure 3 (*Module 45*)
Metric rulers, 30 (*Module 34*)

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Activity 1

Make available to the children the following items: the copies of the two auto-instructional booklets *Busy Bugs 1* and *Busy Bugs 2*, answer sheets for *Busy Bugs 2*, magic pens, drawing paper, pencils, pipe cleaners, three 3-dimensional shapes, metersticks, and rulers. (See *Materials*.) Put pieces of tape labelled "Barb's House" and "Bill's House" on opposite poles of the sphere, and a piece labelled "baseball field" midway between the poles.

Call the children's attention to the booklets and explain how they are to be used. Each child may have a copy of *Busy Bugs 1* and write directly in it. No responses are to be made on the copies of *Busy Bugs 2* since pairs of children will be sharing them. Each child should have an answer sheet and a sheet of drawing paper for *Busy Bugs 2*. The other materials needed can be taken from the table. In both booklets, the children should complete the task or tasks described on one page before going on to the next page. When a pair of children has finished with a copy of *Busy Bugs 2*, they should return the booklet and all materials to the table.

Have the children start working on *Busy Bugs 1*. Ask them to bring their work to you when they have finished. As the children finish *Busy Bugs 1*, assign each child a partner and have four pairs of children continue with *Busy Bugs 2* at their own pace. Start other pairs with *Busy Bugs 2* as the booklets become available.

After all the children have finished *Busy Bugs 1*, go on with *Activity 2*. The children may complete *Busy Bugs 2* as time permits.

Materials

Busy Bugs 1, 30 booklets (*Module 45*)
Busy Bugs 2, 4 booklets (*Module 45*)
Busy Bugs 2, Answer Sheet, 1 spirit master (*Module 45*)
Magic pens, 8, to be used with *Busy Bugs 2* (*Module 33 and Module 40*)
Drawing paper, 1 sheet for each child
Pencils, 1 for each child
Pipe cleaners, 1 package (*Module 45*)
Shapes, 3, plastic, 1 sphere, 1 cylinder, and 1 cone (*Module 45*)
Metersticks, 10 (*Module 34*)
Metric rulers, 30 (*Module 34*)

Train Track 1

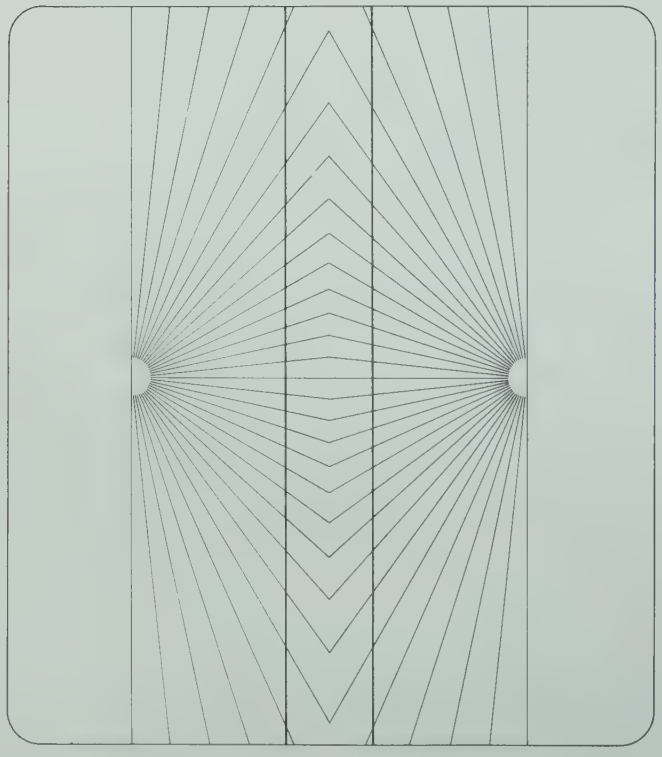

FIGURE 2

Train Track 2

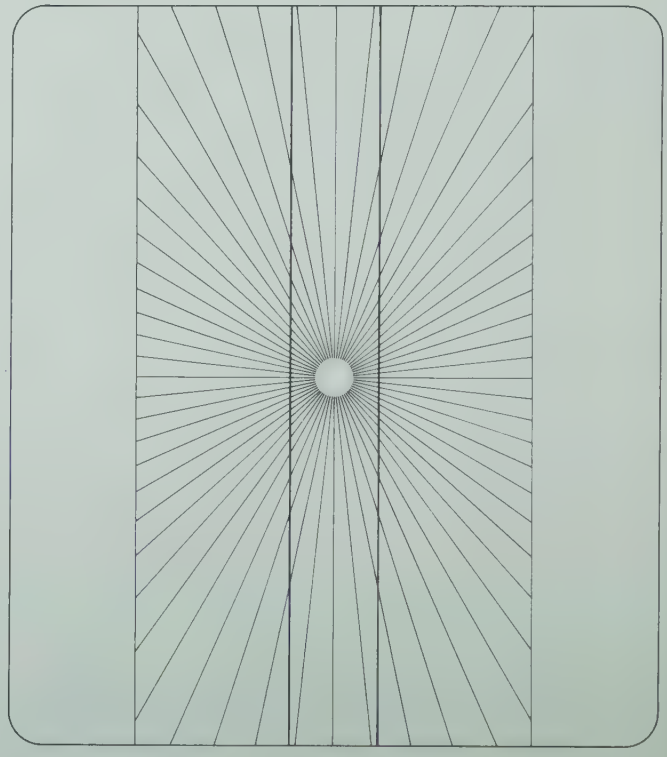

FIGURE 3

Activity 2

Make the room as dark as possible for this activity. Cover the lens of a flashlight with the colored cellophane. Help the children recall several two-dimensional shapes by drawing "light pictures" of these with the lighted flashlight. As you trace the outline of a particular shape, ask the children what it is. If you feel the room is not dark enough, suggest that the children "dim" their eyes by squinting a bit. This has the effect of making everything seem blurred. The contrast between the light and the background will be strengthened and the children will be able to concentrate on the pattern that you trace.

Now have the children try outlining the shapes too. Distribute to each group flashlights, each with a piece of cellophane covering the lens. Let the children take turns outlining and identifying "light pictures". When all the children are able to identify the shapes, use the flashlight to suggest the paths of moving objects, rather than the outlines of shapes. Ask them how Barb walks, or how Bill might walk his dog.

Encourage the children to use the flashlights to trace simple paths of familiar moving objects. How does a train go down the track? How does a snake move? Gradually encourage the children to display more complex, intricate paths, such as that of a person delivering newspapers or that of a gas-station attendant servicing a car. As the children take turns, each child should think of how something moves and then use a flashlight to trace the path in the darkness. The others in the group can each draw the path on a sheet of paper and try to guess what object the leader has in mind. It will be more important for the children to draw the path than for them to guess the object or vehicle.

Turn the lights on and make a diagram on the chalkboard to classify the kinds of motions that the children have been tracing. You might use the classification scheme suggested in the *Rationale*. If so, place emphasis on the first stage and use the words *linear* and *nonlinear*.

Materials

Flashlights, 6, (*Module 45*)
Cellophane, colored brightly (*Module 45*)
Drawing paper, several sheets for each child
Pencils, 1 for each child

Activity 3

Ask the children what a circle is. Ask them how they know that a circle-like shape is really a circle. Accept several responses; then tell the children that mathematicians have a special way of describing a circle. They say a circle is a set of points that are all the same distance from another point called the center. If your children have difficulty understanding the concept *set of points*, you might say that a circle is a curved line that is everywhere the same distance from a point called the center.

Tell the children that you will show them a way to draw circles based on the description of a circle that they have just made. Divide the children into groups of three. Give each group a piece of string 40 centimeters long, a pencil, and a large piece of newsprint. Have each team tie a fixed open loop in each end of the string. Have one child in each team place the pencil through one loop and his or her index finger through the second loop. The child should then place his index finger firmly down on the middle of the piece of newsprint. With his index finger acting as the center of the circle, the child should then trace out a path around the center with the pencil, keeping the string taut at all times. Have each child practice constructing circles until all the children can do it easily.

Next, invite the children to stand around you so that they can see what you do. With a thumbtack, fasten a cardboard disk to the center of one end of a wooden dowel. Stick a colored map pin into the face of the disk near the edge. Whirl the disk with your hand and ask the children what path is traced by the map pin. Let several children try it. They should agree that the map pin traces a circular path and that both the map pin and the disk have demonstrated *circular motion*.

Now roll the disk on the table top. Ask the children what path they think the map pin is tracing now. Give a neutral or noncommital response to their guesses. They may argue that the path is again a circle. Be equally insistent that they may not be correct, and urge them to watch carefully as you roll the disk. Ask what path the thumbtack at the center of the disk travels as the disk rolls across the table top. Some children will see that its path is a straight line. Encourage discussion and any ideas for finding out more about the path of the map pin and of the thumbtack. The following optional activity suggests one way to do this.

Materials

String, 10 pieces, each 40 cm long (*Module 35*)
Pencils, 10
Newsprint, 10 large sheets
Cardboard disk, 1, having a 30-cm diameter
Dowel, 1, wooden (*Module 45*)
Thumbtack, 1
Map pin, 1, colored

Activity 4 (Optional)

If any of the children have *Spirographs* (see Figure 4) at home and are willing to bring their sets into class, have them do so. Divide the children into groups to work with the *Spirographs.* Each *Spirograph* will accommodate two groups. If only one or two *Spirographs* are available, have small groups work at different times.

Give each group of children some paper and pencils of four different colors. The two straight pieces in the *Spirograph* are analogous to the table top of the dowel-and-disk activity. Each notched wheel is analogous to the disk. Point out to the children that there are many holes in each wheel, forming a swirl pattern from near the edge of the wheel to near the center, and that a pencil point can be inserted in each hole. The hole nearest the edge corresponds to the map pin at the edge of the cardboard disk.

Hold one straight piece of the *Spirograph* on a piece of paper, fit the notches on one of the smaller wheels against the notches on the straight piece, and insert a pencil in the hole at the edge of the wheel. As the pencil pulls the wheel along the track, it draws the path of the hole's motion.

Suggest that each child draw the track produced by the movement of every second, third, or fourth hole (depending on the number of holes in the wheel used), using a different colored pencil for each hole. (See Figure 4.) The children will note that each track drawn traces a *nonlinear, noncircular path.*

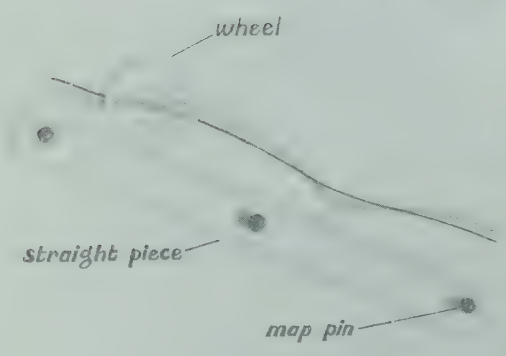

FIGURE 4

Now have the groups use the two wheels that they have not yet used. Ask the children to make additional tracings for comparison. They might, for instance, superimpose the tracings made with the pencil in the outermost hole for each of the three wheels; then on a separate sheet, superimpose those tracings for the third or fourth hole on each wheel; and so on. If the children do this, they will discover that the smallest wheel makes more peaks and troughs in a certain distance than the largest wheel.

Discuss the meaning of the peaks and troughs until some child points out that the distance from trough to trough, or from peak to peak, means one full turn, or one rotation, of the wheel. Someone should also state that little wheels have to turn around, or rotate, more times than big wheels to go the same distance. Some of the children may also notice that the closer the hole is to the center, the less curvy is the line drawn. Relate this to the path of the dowel-and-disk thumbtack, which was in the center of the disk.

Encourage the children to make displays of their drawings with the *Spirograph* as a further description of the motion-classification scheme described in the *Rationale.*

Materials

Drawing paper, several sheets for each group
Colored pencils, 4 different colors for each group
Spirograph, 1 or more, Figure 4

Generalizing Experiences

Point out a merry-go-round or any other rotating playground apparatus. While children are playing on it, discuss the motion of children near the center and of those out toward the edge. Suggest that a child release a ball on the ground from the rotating merry-go-round. Ask them what path the ball traces over the ground.

Ask the children to study the possible paths of Busy Bugs, Barb and Bill on an irregular three-dimensional object, such as a stuffed animal. Ask them to identify any straight paths and any open and closed curved paths. Suggest that they compare the lengths of the paths by measuring with pipe cleaners or string. Also have the children identify flat, or plane, surfaces and curved surfaces on the object.

Materials

Ball, 1 (*Module 37*)
Stuffed animal, 1, or other irregular three-dimensional shape
Pipe cleaners, several (*Module 45*), or string
Metric rulers, 30 (*Module 34*)

APPRAISAL

If one of the children is willing to bring a small train and track to school, set it up in front of the room. If this is not possible, devise a facsimile of a train track, using string for instance, and of a train, perhaps using a cube or a ball. Ask the children to write answers on a piece of paper to questions like those that follow. The last two questions require that you do some demonstrating.

Is the track a straight or curved path?

Is any part of it a straight path?

Is the track a closed or open path?

Does the track lie on a flat, or a plane, surface?

I am going to put a book under the track at this point. Does the track now lie on a flat, or a plane, surface? Watch as I run the train on the track. What kind of motion is the train demonstrating?

Ask the children to look around the room and to tell you if they see anything moving in a circular path. They may respond that the end of the second hand on the clock is moving in a circular path; if a record is turning on a phonograph, they may say a point on the edge of the record; the wheels of a toy train; and so on.

Ask several children to use a meterstick to find a surface in the room that is flat and a surface that is not flat. Then have them show the other children how they know.

Materials

Small train and track, 1, or a facsimile
Writing paper, 1 sheet for each child
Pencils, 1 for each child
Metersticks, 10 (*Module 34*)

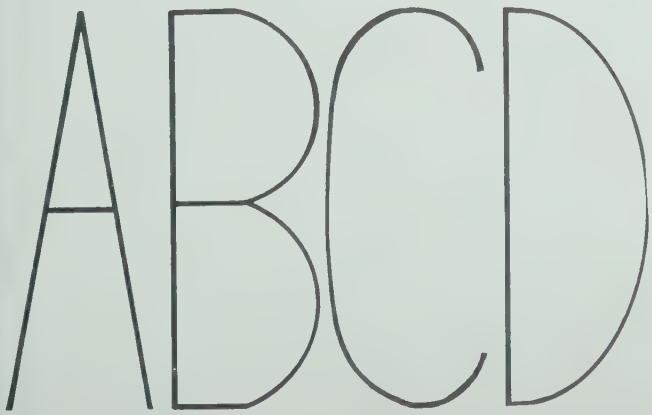

FIGURE 5

COMPETENCY MEASURE

TASK 1 (Objective 1): Show the child a copy of Figure 5. Say, Point to a curved path in the figure. The child should point to a curved section of one of the letters *B, C,* or *D.*

TASK 2 (Objective 2): Give the child a 250-milliliter clear plastic container and a crayon, and say, Draw a straight path on this container. The child should draw a straight line on the bottom of the container, or straight up the side of the container.

TASK 3 (Objective 3): Give the child a piece of cardboard or the top of a cardboard carton, at least 30 x 30 centimeters. Also give the child a meterstick or other straightedge. Say, Show me how you would find out if this piece of cardboard is a flat surface, and tell me how you decide whether or not it is flat. The child should apply the edge of the meterstick to the surface of the cardboard in a number of different directions, observe the way the meterstick and cardboard are touching, and describe what he or she is doing.

TASK 4 (Objective 4): Ask the child to close his eyes and move a forefinger the way a rock moves when it is dropped. Then ask the child to move his finger the way a rock moves when it is thrown out into the water. Now ask, Which one was linear, or straight motion? The child should identify the first movement.

TASK 5 (Objective 5): Remind the child of the movements he made to imitate the movement of a dropped rock and a thrown rock. Ask the child to repeat those motions again. Now ask the child to demonstrate the motion of a rock that is being whirled on the end of a string. Then ask, Which of the three motions is circular? The child should identify in some way the motion of the whirling rock.

Materials

Container, 1, 250-ml, clear plastic (*Module 31*)
Crayon, 1
Cardboard, 1 piece, 30 x 30 cm
Meterstick, 1 (*Module 34*), or other straightedge

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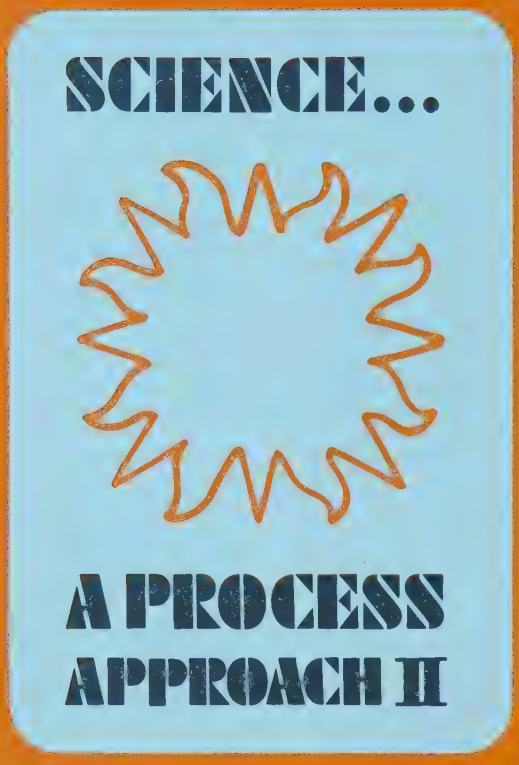
45 Using Space/Time Relationships/g



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SCIENCE... A PROCESS APPROACH II

MODULE

45

Using Space/Time Relationships/g

Lines, Curves, and Surfaces

OBJECTIVES

At the end of this module the child should be able to

1. *IDENTIFY* and *NAME* straight and curved paths on a plane surface.
2. *CONSTRUCT* curved paths on the surface of a sphere, a cone, and a cylinder and straight paths on a cone and cylinder.
3. *DEMONSTRATE* how to determine whether a surface is a plane surface.
4. *DISTINGUISH* linear from nonlinear motion.
5. *IDENTIFY* and *NAME* circular motion.

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AAAS

SEQUENCE

DESCRIBING the forces acting on moving objects.
MODULE 54 Measuring/j
DISTINGUISHING linear from nonlinear motion, and *IDENTIFYING* and *NAMING* circular motion.
THIS MODULE Using Space/Time Relationships/g
IDENTIFYING and *NAMING* straight and curved paths on a plane surface and *CONSTRUCTING* straight and/or curved paths on the surfaces of solid shapes.
THIS MODULE Using Space/Time Relationships/g
DEMONSTRATING how to determine whether a surface is a plane surface.
THIS MODULE Using Space/Time Relationships/g
DEMONSTRATING a procedure for measuring and recording changes in the position of an object.
MODULE 27 Communicating/c
IDENTIFYING objects that have line or plane symmetry.
MODULE 35 Using Space/Time Relationships/f

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

This module provides an introduction to motion in linear and nonlinear paths on plane and curved surfaces. In order to better understand motion on particular kinds of paths, the children first study straight lines and curved lines on plane surfaces and on the surfaces of three-dimensional shapes.

In general, throughout the module, terms that already have meaning for the child are used. To illustrate, no distinction is made between a straight line and a line segment; the "lines" observed are simply called "straight line paths" or "straight paths". A curve that returns to the starting point is called a "closed path," and is distinguished from a curve that is not closed. A circle, of course, is a closed path. The idea of a closed path is particularly useful in the study of area.

Two booklets on straight and curved lines and surfaces are provided as auto-instructional instruments in *Activity 1.* As the children complete the tasks in the booklets, they acquire the skills defined in Objectives 1, 2, and 3. Have as many of the children as possible complete the tasks in the first of the two booklets before beginning *Activities 2* and *3.*

Objectives 4 and 5 are concerned with motion. Although the concepts of paths and motion are distinct, every motion implies a path. Both concepts are thus necessarily involved in the activities. This difference need not be emphasized with the children at this time, but clarify the concepts for them if they ask.

One way to classify motion is shown in Figure 1. This scheme is the basis for ordering the activities. *Activity 2* treats linear and nonlinear motion and paths. *Activity 3* and optional *Activity 4* introduce circular and noncircular motion and paths.

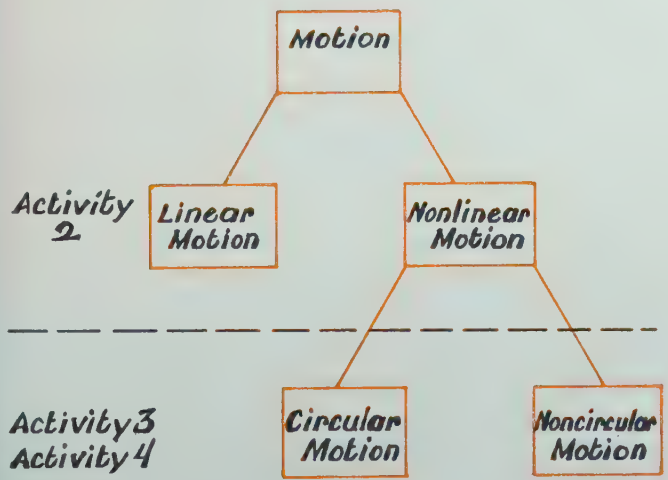

FIGURE 1

Vocabulary

straight line	linear
curved line	nonlinear
closed path	circle
open path	circular
curved surface	noncircular
flat surface	rotate
plane surface	rotation

INSTRUCTIONAL PROCEDURE

Introduction

Ask the children to hold up their hands if they know what a straight line looks like. All or nearly all hands should go up. Then say that you have run into a little problem and need their help. Tell a story about a friend who drew two pictures of railroad tracks. She was not sure when she finished that a train could run on the tracks if they were built in the way she drew them. Show the children the optical illusions in Figures 2 and 3 on the next page. Ask which set of tracks the children think the train will be able to run on. The illusions will make the question difficult to answer. Be noncommittal and let the children discuss the contradiction the illusions produce.

While interest is still high, ask the children how many ways they can think of to test the lines to find out if they are straight. Give each child a copy of *Train Track 1* and *Train Track 2.* Encourage the children to show each other various methods for examining the lines for straightness. One child might sight along the plane of the paper; another might place a straight-edge next to one of the lines. If a child suggests checking the distance between the lines at different places, call everyone's attention to it and ask all the children to do this.

At some time in the course of the following activities, as you refer to paths and motion, begin to use the terminology in the *Vocabulary* list. When the children ask what a new word means, tell them and spell it for them.

Materials

Train Track 1, 1 spirit master, Figure 2 (*Module 45*)
Train Track 2, 1 spirit master, Figure 3 (*Module 45*)
Metric rulers, 30 (*Module 34*)

Activity 1

Make available to the children the following items: the copies of the two auto-instructional booklets *Busy Bugs 1* and *Busy Bugs 2*, answer sheets for *Busy Bugs 2*, magic pens, drawing paper, pencils, pipe cleaners, three 3-dimensional shapes, metersticks, and rulers. (See *Materials*.) Put pieces of tape labelled "Barb's House" and "Bill's House" on opposite poles of the sphere, and a piece labelled "baseball field" midway between the poles.

Call the children's attention to the booklets and explain how they are to be used. Each child may have a copy of *Busy Bugs 1* and write directly in it. No responses are to be made on the copies of *Busy Bugs 2* since pairs of children will be sharing them. Each child should have an answer sheet and a sheet of drawing paper for *Busy Bugs 2*. The other materials needed can be taken from the table. In both booklets, the children should complete the task or tasks described on one page before going on to the next page. When a pair of children has finished with a copy of *Busy Bugs 2*, they should return the booklet and all materials to the table.

Have the children start working on *Busy Bugs 1*. Ask them to bring their work to you when they have finished. As the children finish *Busy Bugs 1*, assign each child a partner and have four pairs of children continue with *Busy Bugs 2* at their own pace. Start other pairs with *Busy Bugs 2* as the booklets become available.

After all the children have finished *Busy Bugs 1*, go on with *Activity 2*. The children may complete *Busy Bugs 2* as time permits.

Materials

Busy Bugs 1, 30 booklets (*Module 45*)
Busy Bugs 2, 4 booklets (*Module 45*)
Busy Bugs 2, Answer Sheet, 1 spirit master (*Module 45*)
Magic pens, 8, to be used with *Busy Bugs 2* (*Module 33 and Module 40*)
Drawing paper, 1 sheet for each child
Pencils, 1 for each child
Pipe cleaners, 1 package (*Module 45*)
Shapes, 3, plastic, 1 sphere, 1 cylinder, and 1 cone (*Module 45*)
Metersticks, 10 (*Module 34*)
Metric rulers, 30 (*Module 34*)

Train Track 1

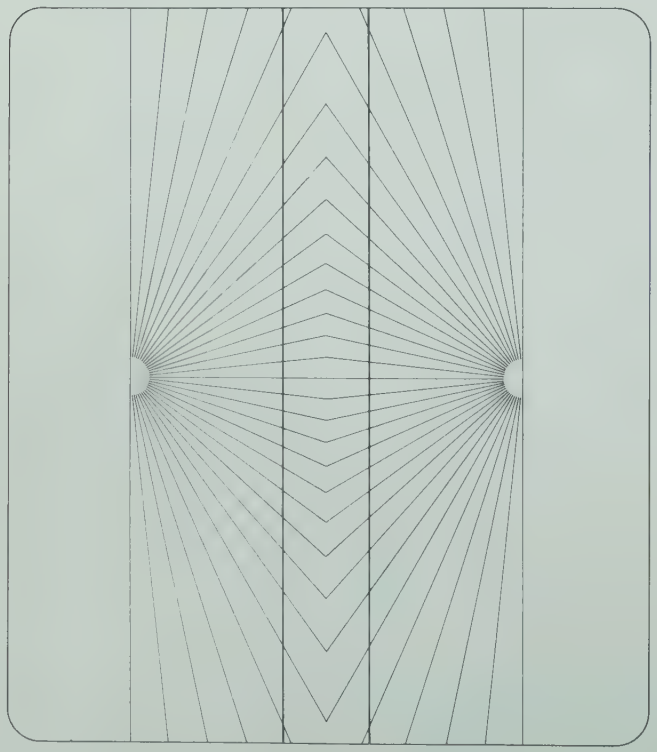

FIGURE 2

Train Track 2

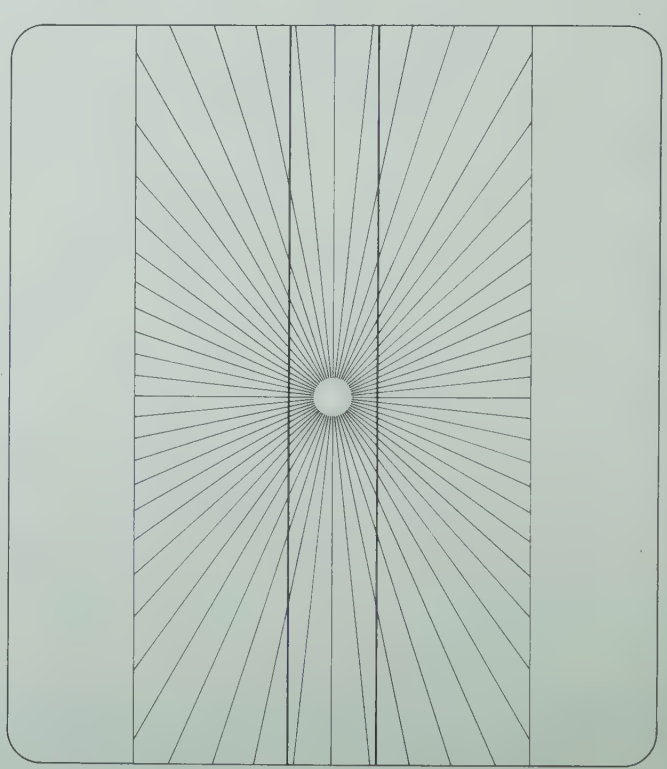

FIGURE 3

Activity 2

Make the room as dark as possible for this activity. Cover the lens of a flashlight with the colored cellophane. Help the children recall several two-dimensional shapes by drawing "light pictures" of these with the lighted flashlight. As you trace the outline of a particular shape, ask the children what it is. If you feel the room is not dark enough, suggest that the children "dim" their eyes by squinting a bit. This has the effect of making everything seem blurred. The contrast between the light and the background will be strengthened and the children will be able to concentrate on the pattern that you trace.

Now have the children try outlining the shapes too. Distribute to each group flashlights, each with a piece of cellophane covering the lens. Let the children take turns outlining and identifying "light pictures". When all the children are able to identify the shapes, use the flashlight to suggest the paths of moving objects, rather than the outlines of shapes. Ask them how Barb walks, or how Bill might walk his dog.

Encourage the children to use the flashlights to trace simple paths of familiar moving objects. How does a train go down the track? How does a snake move? Gradually encourage the children to display more complex, intricate paths, such as that of a person delivering newspapers or that of a gas-station attendant servicing a car. As the children take turns, each child should think of how something moves and then use a flashlight to trace the path in the darkness. The others in the group can each draw the path on a sheet of paper and try to guess what object the leader has in mind. It will be more important for the children to draw the path than for them to guess the object or vehicle.

Turn the lights on and make a diagram on the chalkboard to classify the kinds of motions that the children have been tracing. You might use the classification scheme suggested in the *Rationale*. If so, place emphasis on the first stage and use the words *linear* and *nonlinear*.

Materials

Flashlights, 6, (*Module 45*)
Cellophane, colored brightly (*Module 45*)
Drawing paper, several sheets for each child
Pencils, 1 for each child

Activity 3

Ask the children what a circle is. Ask them how they know that a circle-like shape is really a circle. Accept several responses; then tell the children that mathematicians have a special way of describing a circle. They say a circle is a set of points that are all the same distance from another point called the center. If your children have difficulty understanding the concept *set of points*, you might say that a circle is a curved line that is everywhere the same distance from a point called the center.

Tell the children that you will show them a way to draw circles based on the description of a circle that they have just made. Divide the children into groups of three. Give each group a piece of string 40 centimeters long, a pencil, and a large piece of newsprint. Have each team tie a fixed open loop in each end of the string. Have one child in each team place the pencil through one loop and his or her index finger through the second loop. The child should then place his index finger firmly down on the middle of the piece of newsprint. With his index finger acting as the center of the circle, the child should then trace out a path around the center with the pencil, keeping the string taut at all times. Have each child practice constructing circles until all the children can do it easily.

Next, invite the children to stand around you so that they can see what you do. With a thumbtack, fasten a cardboard disk to the center of one end of a wooden dowel. Stick a colored map pin into the face of the disk near the edge. Whirl the disk with your hand and ask the children what path is traced by the map pin. Let several children try it. They should agree that the map pin traces a circular path and that both the map pin and the disk have demonstrated *circular motion*.

Now roll the disk on the table top. Ask the children what path they think the map pin is tracing now. Give a neutral or noncommital response to their guesses. They may argue that the path is again a circle. Be equally insistent that they may not be correct, and urge them to watch carefully as you roll the disk. Ask what path the thumbtack at the center of the disk travels as the disk rolls across the table top. Some children will see that its path is a straight line. Encourage discussion and any ideas for finding out more about the path of the map pin and of the thumbtack. The following optional activity suggests one way to do this.

Materials

String, 10 pieces, each 40 cm long (*Module 35*)
Pencils, 10
Newsprint, 10 large sheets
Cardboard disk, 1, having a 30-cm diameter
Dowel, 1, wooden (*Module 45*)
Thumbtack, 1
Map pin, 1, colored

Activity 4 (Optional)

If any of the children have *Spirographs* (see Figure 4) at home and are willing to bring their sets into class, have them do so. Divide the children into groups to work with the *Spirographs*. Each *Spirograph* will accommodate two groups. If only one or two *Spirographs* are available, have small groups work at different times.

Give each group of children some paper and pencils of four different colors. The two straight pieces in the *Spirograph* are analogous to the table top of the dowel-and-disk activity. Each notched wheel is analogous to the disk. Point out to the children that there are many holes in each wheel, forming a swirl pattern from near the edge of the wheel to near the center, and that a pencil point can be inserted in each hole. The hole nearest the edge corresponds to the map pin at the edge of the cardboard disk.

Hold one straight piece of the *Spirograph* on a piece of paper, fit the notches on one of the smaller wheels against the notches on the straight piece, and insert a pencil in the hole at the edge of the wheel. As the pencil pulls the wheel along the track, it draws the path of the hole's motion.

Suggest that each child draw the track produced by the movement of every second, third, or fourth hole (depending on the number of holes in the wheel used), using a different colored pencil for each hole. (See Figure 4.) The children will note that each track drawn traces a *nonlinear, noncircular path.*

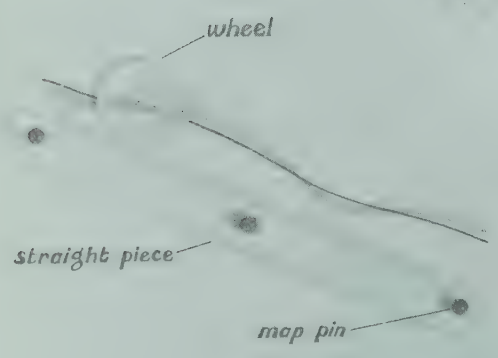

FIGURE 4

Now have the groups use the two wheels that they have not yet used. Ask the children to make additional tracings for comparison. They might, for instance, superimpose the tracings made with the pencil in the outermost hole for each of the three wheels; then on a separate sheet, superimpose those tracings for the third or fourth hole on each wheel; and so on. If the children do this, they will discover that the smallest wheel makes more peaks and troughs in a certain distance than the largest wheel.

Discuss the meaning of the peaks and troughs until some child points out that the distance from trough to trough, or from peak to peak, means one full turn, or one rotation, of the wheel. Someone should also state that little wheels have to turn around, or rotate, more times than big wheels to go the same distance. Some of the children may also notice that the closer the hole is to the center, the less curvy is the line drawn. Relate this to the path of the dowel-and-disk thumbtack, which was in the center of the disk.

Encourage the children to make displays of their drawings with the *Spirograph* as a further description of the motion-classification scheme described in the *Rationale.*

Materials

Drawing paper, several sheets for each group
Colored pencils, 4 different colors for each group
Spirograph, 1 or more, Figure 4

Generalizing Experiences

Point out a merry-go-round or any other rotating playground apparatus. While children are playing on it, discuss the motion of children near the center and of those out toward the edge. Suggest that a child release a ball on the ground from the rotating merry-go-round. Ask them what path the ball traces over the ground.

Ask the children to study the possible paths of Busy Bugs, Barb and Bill on an irregular three-dimensional object, such as a stuffed animal. Ask them to identify any straight paths and any open and closed curved paths. Suggest that they compare the lengths of the paths by measuring with pipe cleaners or string. Also have the children identify flat, or plane, surfaces and curved surfaces on the object.

Materials

Ball, 1 (*Module 37*)
Stuffed animal, 1, or other irregular three-dimensional shape
Pipe cleaners, several (*Module 45*), or string
Metric rulers, 30 (*Module 34*)

APPRAISAL

If one of the children is willing to bring a small train and track to school, set it up in front of the room. If this is not possible, devise a facsimile of a train track, using string for instance, and of a train, perhaps using a cube or a ball. Ask the children to write answers on a piece of paper to questions like those that follow. The last two questions require that you do some demonstrating.

Is the track a straight or curved path?

Is any part of it a straight path?

Is the track a closed or open path?

Does the track lie on a flat, or a plane, surface?

I am going to put a book under the track at this point. Does the track now lie on a flat, or a plane, surface? Watch as I run the train on the track. What kind of motion is the train demonstrating?

Ask the children to look around the room and to tell you if they see anything moving in a circular path. They may respond that the end of the second hand on the clock is moving in a circular path; if a record is turning on a phonograph, they may say a point on the edge of the record; the wheels of a toy train; and so on.

Ask several children to use a meterstick to find a surface in the room that is flat and a surface that is not flat. Then have them show the other children how they know.

Materials

Small train and track, 1, or a facsimile
Writing paper, 1 sheet for each child
Pencils, 1 for each child
Metersticks, 10 (*Module 34*)

FIGURE 5

COMPETENCY MEASURE

TASK 1 (Objective 1): Show the child a copy of Figure 5. Say, Point to a curved path in the figure. The child should point to a curved section of one of the letters *B*, *C*, or *D*.

TASK 2 (Objective 2): Give the child a 250-milliliter clear plastic container and a crayon, and say, Draw a straight path on this container. The child should draw a straight line on the bottom of the container, or straight up the side of the container.

TASK 3 (Objective 3): Give the child a piece of cardboard or the top of a cardboard carton, at least 30 x 30 centimeters. Also give the child a meterstick or other straightedge. Say, Show me how you would find out if this piece of cardboard is a flat surface, and tell me how you decide whether or not it is flat. The child should apply the edge of the meterstick to the surface of the cardboard in a number of different directions, observe the way the meterstick and cardboard are touching, and describe what he or she is doing.

TASK 4 (Objective 4): Ask the child to close his eyes and move a forefinger the way a rock moves when it is dropped. Then ask the child to move his finger the way a rock moves when it is thrown out into the water. Now ask, Which one was linear, or straight motion? The child should identify the first movement.

TASK 5 (Objective 5): Remind the child of the movements he made to imitate the movement of a dropped rock and a thrown rock. Ask the child to repeat those motions again. Now ask the child to demonstrate the motion of a rock that is being whirled on the end of a string. Then ask, Which of the three motions is circular? The child should identify in some way the motion of the whirling rock.

Materials

Container, 1, 250-ml, clear plastic (*Module 31*)
Crayon, 1
Cardboard, 1 piece, 30 x 30 cm
Meterstick, 1 (*Module 34*), or other straightedge

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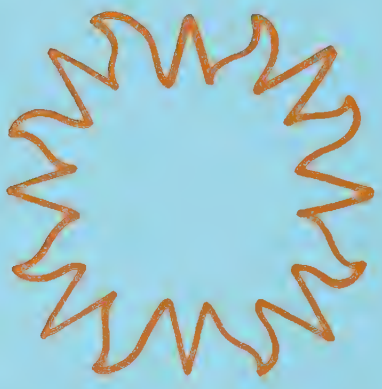
45 Using Space/Time Relationships/g

SCIENCE...



A PROCESS APPROACH II

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SCIENCE...
A PROCESS
APPROACH II

MODULE
46

Inferring /c

Observations and Inferences

OBJECTIVES

At the end of this module the child should be able to

1. *DISTINGUISH* between observations and inferences.
2. *CONSTRUCT* one or more inferences from an observation or a set of observations.
3. *DEMONSTRATE* that inferences may need to be revised on the basis of additional observations.

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SEQUENCE

CONSTRUCTING an inference based on observations of the effect of a liquid on plant and animal material.
MODULE 58 Inferring/e
DESCRIBING observations that can be used to test an inference.
MODULE 52 Inferring/d
CONSTRUCTING one or more inferences from an observation or set of observations.
THIS MODULE Inferring/c
DEMONSTRATING that inferences may need to be revised on the basis of additional observations.
THIS MODULE Inferring/c
DISTINGUISHING between statements that are observations and explanations of observations and *IDENTIFYING* explanations as inferences.
MODULE 33 Inferring/a
DISTINGUISHING between inferences that account for all of the stated observations and inferences that do not.
MODULE 40 Inferring/b
CONSTRUCTING inferences in terms of likelihood rather than certainty.
MODULE 33 Inferring/a

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

In two modules, *What's Inside? Inferring a, Module 33* and *How Certain Can You Be?, Inferring b, Module 40,* the child began to distinguish between observations (what a person sees, smells, hears, touches, and tastes) and inferences (what a person thinks is responsible for what is observed, or how a person explains his observations). Now the child continues to make this distinction by identifying statements, which others make, as observations or inferences. In subsequent modules, the child develops skill in testing and revising inferences.

Learning to make careful and valid inferences in scientific work requires a critical attitude toward one's own inferences as well as those of others. From now on, try to develop this critical attitude by reinforcing the distinction between an inference and an observation whenever possible. Emphasize that inferences must be supported by observations; statements that are not supported by observations are guesses and should be discouraged. Ask questions such as these: Is that an observation? Did you actually *see* a dog run away with your ball? Or is that an inference? In other words, is that what you *think* may have happened?

In the *Introduction* and *Activity 1* the children examine cartoons in which the cartoon characters make observations and inferences. The children classify the characters' statements as observations or inferences, and then critically examine the basis for each inference.

Activities 2 and *3* demonstrate the usefulness of inferences in the realm of biology. It is usually impossible to observe all aspects of an organism in relation to its environment. Frequently, only traces of an organism or of its activity can actually be observed. The biologist can infer many of the characteristics of organisms by observing such traces as animals' scratches, gnaw marks, droppings, remains, parts of homes, and footprints, and plants' seeds, leaves, bark, wood, and roots. After carefully observing organisms or their traces, the scientist can often infer much about relationships between the organisms and their environments.

During the activities in this module, let the children examine various materials, state their observations, and draw inferences from those observations. Emphasize the importance of making careful, intelligent inferences based on careful observations.

You can add to the children's enjoyment of these activities by showing films or filmstrips of animals in your locale. Most state departments of education or conservation can give you information about such materials. This is also a good time to encourage the children to do outside reading about animals and their environment.

Vocabulary

feature trace

INSTRUCTIONAL PROCEDURE

Introduction

Give each child a cartoon booklet entitled *What Do We Observe? How Do We Infer?* and ask the children to look at *Cartoon One*. Tell them that the cartoon shows two groups of children having an argument. Ask the children to read the cartoon story to find out just what the argument is about, and what observations and inferences the cartoon characters have made. If the children do not remember the distinction between observation and inference, remind them that an observation is something that a person sees, touches, hears, smells, tastes—in other words, something that a person experiences with his senses. Explain that an inference is a person's idea about how his observations might be explained or accounted for.

You may wish to have the cartoon story read aloud. After the children have read or heard the story, begin a discussion by asking questions similar to those that follow.

What was the disagreement about?

Did one of the first two children see one of the Thompsons' children break the limb?

Why did the first two children infer that one of the Thompsons broke the limb?

What does the Thompson girl suggest?

Did she see the wind break the limb?

Even if she broke the limb, might she suggest that the wind did it?

Would this be telling a fib?

How can we decide who is right?

After the class has discussed *Cartoon One*, have them read *Cartoon Two*. Engage them in a discussion of what the cartoon characters observed and inferred.

Materials

What Do We Observe? How Do We Infer?, 30 cartoon booklets (*Module 46*)

Activity 1

Have each child read at least four of the remaining six cartoons in the booklet. Since all six cartoon stories may be too many for the children to consider at one time, you might save one or two for use later during this module, or even while another module is being taught. Call the children's attention to *Cartoon Three* first. To start the discussion ask one or more volunteers to tell the other children the story of the cartoon. Suggest that the children distinguish between observations and inferences made by the cartoon characters.

When the children have picked out those statements that are inferences, ask what further observations would support or would not support the inferences. After the discussion, ask the children to answer the questions beneath *Cartoon Three*.

Continue the activity by having the children read two or three of the remaining cartoons, but encourage the children to answer the questions for these cartoons without discussion. You may want to point out that not all the statements beneath the cartoons were made by the cartoon characters. After the children have completed the questions, discuss one or more cartoons with the group. If there is any disagreement among the children about which statements are observations and which are inferences, remind the children that an observation is something that a person sees, hears, smells, touches, or tastes—in other words, something a person experiences directly with his senses. Those statements that are observations include the following: for *Cartoon Three*, statement 1 and 3; for *Cartoon Four*, statement 1; for *Cartoon Five*, statements 1 and 2; for *Cartoon Six*, statements 1 and 3. The rest of the statements given for the four cartoons are inferences. The questions for *Cartoons Seven* and *Eight* are intended to provoke thought, and will probably elicit a variety of answers.

Encourage the children to suggest additional inferences that might be made about the situations in each of the cartoons, and to suggest additional observations that could be made to support any of the inferences. To add variety, you may want to have the children stage one or two of the cartoons as short plays. Do not discourage the children if they wish to extend the conversation of the cartoon characters.

Materials

What Do We Observe? How Do We Infer?, 30 cartoon booklets (*Module 46*)

Activity 2

Display the wall chart of a woodland scene (see Figure 1) and call the children's attention to it. Initiate a discussion of this scene by asking the children what they see in the picture. They will probably mention trees, grass, and a log, all of which are easily observable. Ask the children what they observe that might indicate that animals live there or have been there. The children may point out the tiny holes in the trees, the large hole in the foreground, and the mound of dirt in front of one of the trees. Point out to the children that they are inferring the presence of animals on the basis of observations.

Give each child a hazelnut, walnut, pecan, or almond, all of which have shells that are difficult to open. After the children have had an opportunity to observe characteristics such as texture, shape, symmetry, hardness, and color of the nuts, give each child a copy of the woodland scene and direct their attention to the acorns, particularly the broken ones, under the tree.

Ask how the nuts on the ground could have been broken. Then ask the children how they could crack their own nut shells. The children's suggestions might include jumping on the nut, biting it, prying it open with their fingers, squeezing it between their hands, and using a nutcracker. Ask if animals would use any of the methods suggested; the children will probably mention biting. Then ask how animals might use their paws to help them crack nuts; if the children don't explain, point out that an animal often uses its paws to hold a nut in place. Finally, ask the children what they might infer about the characteristics of an animal that is able to crack a nut by biting. The children should suggest characteristics such as strong jaws, sharp teeth, and paws that can hold a nut.

Now give the children nutcrackers. Point out that the inner surfaces have small teeth and ask what the purpose of these teeth is. Someone will probably say that the teeth hold the nut and help to crack it. Let the children suggest the names of animals with characteristics that would enable them to crack nuts. Squirrels, chipmunks, and gerbils are such animals.

Materials

Woodland Scene, 1 wall chart, Figure 1 (*Module 46*)
Nuts with shells, 1 nut for each child, assortment including hazelnuts, walnuts, pecans, and almonds
Woodland scene, 30 sheets (*Module 46*)
Nutcrackers, 5 (*Module 46*)

FIGURE 1

Activity 3

Divide the children into groups of five and give each group a set of animals' footprints, which you have cut out beforehand (see Figure 2); the names of the animals should not appear on the cutouts. After the groups have studied the footprints, ask the children to state observations about them. Then ask questions such as the following: How large are the animals? How many toes do they have? Do they have claws? Do they climb trees? Can you infer what the animals eat? Discuss with the children all of the inferences they can make. The children cannot, of course, make inferences about what the animals eat on the basis of the footprints, and it is sometimes difficult to infer the number of toes or claws.

Show the children pictures of an elephant, a black bear, a bison, a sheep, a gray squirrel, a cat, and a snowshoe rabbit. As you display each picture, explain that the animal made one or more of the cutout footprints. Ask the children to select the footprint (or footprints) that goes with the animal in the picture. Discuss the children's choices and any other inferences the children can make from the combined pictures and footprints. Ask the children if they want to change any of their original inferences, and why they want to do so.

FIGURE 2

Next, show the children the picture of footprints on the beach (see Figure 3). Ask the children to tell about the footprints. The children might suggest that the footprints were made by people going for a walk with their dog. Ask whether they think all of the people are the same age. (Probably not, because some footprints are almost twice as long as others.) Ask the children to order the sets of footprints from the largest to the smallest.

Footprints on the Beach

FIGURE 3

After the children have discussed the footprints, show them the second picture, which shows three children and a dog on the beach (see Figure 4). Tell the group that these children might have made the footprints in the first picture. Then ask the children to look carefully at both posters again.

Ask the children whether the new observations they can now make support the inferences they made after they looked at the first picture. Do any of their inferences need to be revised? (The children may have noticed that in the first picture the footprints in the foreground are much closer together than those farther along the beach; the running style of the figures in the second poster may suggest that the children were first walking and then started to run at the place where the footprints are farther apart.) Emphasize the idea that inferences must often be changed on the basis of new observations.

Materials

Footprints of Animals, 10 cutouts, Figure 2 (*Module 46*)
Footprints on the Beach, 1 wall chart, Figure 3 (*Module 46*)
Children on the Beach, 1 wall chart, Figure 4 (*Module 46*)

Children on the Beach

FIGURE 4

Generalizing Experiences

The children should do at least one of the following activities. These are listed in order of their desirability.

1. The children might take a field trip to observe some animal tracks and traces and to make inferences about them. Places that would be suitable for such a field trip include wooded areas, meadows, overgrown lots, and so forth. Among other things, the children might look for fruits or seeds that animals eat, animal footprints, remains, and animal homes; you may want to limit the range of observation to one of these categories. Tell the children beforehand not to remove any materials; point out that they are observing, not collecting. If your school system has a science specialist, you might wish to consult this person or arrange for him or her to direct the trip.

The children should keep a record of their observations and inferences. Preferably, the children should make this record during the field trip, but if this is not possible, the children should record their observations immediately after they return to school. The children's records might include both written descriptions and diagrams.

After the group returns to school, discuss the observations that the children made. Encourage the children to make inferences based on their observations. Some of the children's observations should lead to quite reliable inferences; others, to very tentative ones. Warn the children against making a specific identification of any animal on the basis of a slight trace of evidence. Explain the importance of making careful inferences about either the characteristics or behavior of the animal, or both, before attempting identification.

If possible, repeat the trip as the seasons change; tracks in new-fallen snow are especially vivid and exciting.

2. You might take the children on a field trip in the city to observe various kinds of traces and to make inferences. The children might observe tire skid marks, and on the basis of the length of these marks infer the relative speed at which the vehicle was moving when the brakes were applied. Worn stair steps might indicate heavy traffic or long use. Certain kinds of litter on a street might indicate that a parade had passed recently. Damaged monuments might indicate vandalism or air pollution. Other items that the children might observe and make inferences about include footprints in asphalt; traces made in freshly poured concrete; and the general condition of such things as lawns, buildings, windows, and street lamps. Finally, take the children to a park and have them look for traces of city animals, such as squirrels and pigeons.

The children should keep a record of their observations and inferences; the record might include both written descriptions and sketches. When you return to school, discuss what the children observed and inferred.

3. You might take the class on a field trip to a museum of natural history. Many local museums have natural history displays arranged for children that show the various signs or traces that animals leave. Ask the curator to help the children with their observations. Stress the interpretation of clues related to animal activities, and point out that such interpretations are inferences.

Materials

Paper on which to record observations, several sheets for each child
Pencils, 1 for each child

APPRAISAL

Give each child a copy of Figure 5 showing a child fishing. Tell the children to look at the two pictures carefully. As they look at the first picture, ask what inferences they might make to explain why the girl's fishing line is stretched tight. The children will probably make various inferences: "The girl has a fish on her hook;" "the hook is caught on a snag or some heavy object;" "a turtle is biting the hook." Accept any reasonable and substantiated inferences.

Then ask the children to look at the other picture and to make inferences from it. Again accept any reasonable and substantiated inference. Point out that there is a space between the two pictures. Ask each child to infer what a middle picture would show. Encourage each child to draw a picture in the space. As the discussion progresses, it should become apparent that there are many reasonable inferences which the picture could show. For example, the children might suggest pictures of the girl pulling one fish out of the water, receiving one fish from another person on the pier, or receiving two fish from another person on the pier. Point out that these inferences are only guesses, and ask the children what would help them make inferences that are more reliable. The children should realize that more observational evidence is needed.

Now tell the children the following story about the picture: Debbie used a line with two fish hooks. She had been fishing for some time. All of a sudden she felt a tug on her line. When she pulled up her line, she discovered she had caught two fish—one on each hook.

Now ask the children how they might change or add to their drawings. They will probably tell you that they would draw a girl pulling two fish out of the water.

Materials

Child Fishing, 1 spirit master, Figure 5 (*Module 46*)
Pencil or crayons, enough for each child

Child Fishing

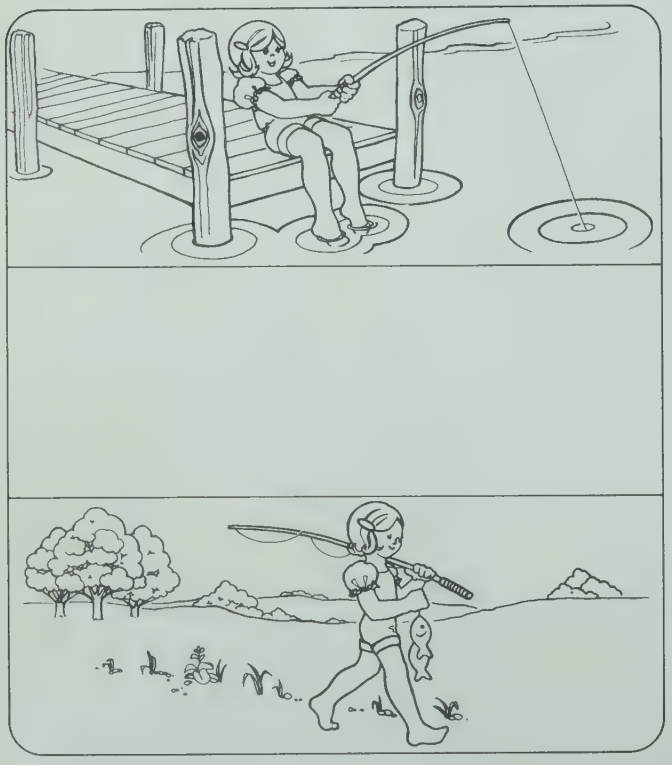

FIGURE 5

COMPETENCY MEASURE

Give the child the picture card of the footprint shown in Figure 6. Say, **Three children saw this footprint while they were on a walk. Each child had something different to say about what he saw. Debbie said, "An animal with sharp claws made that footprint," Tom said, "An animal with sharp teeth made that footprint," Douglas said, "The footprint is as wide as my foot."**

TASK 1 (Objective 1): Ask, **Who made an observation?** Repeat the story once. The child should say, "Douglas."

TASK 2 (Objective 1): Ask, **Who made a reasonable inference?** The child should say, "Debbie."

TASK 3 (Objective 2): Ask, **What more can you infer about the foot of the animal that made this track?** The child should make a reasonable inference, such as one of the following:

a. The animal has widely spaced toes.
b. The animal has five toes.
c. The animal has a padded foot, or paw.
d. The animal has toenails.
e. The animal has curved toes.
f. The animal has long claws.

TASK 4 (Objective 2): Point to the horizontal series of holes in the side of the tree illustrated in the wall chart showing the large woodland scene. Ask the child to examine the holes carefully. Give the child the picture card illustrating birds' heads. Say, **Look at the beaks carefully. What bird do you infer could make the holes in the tree?** The child should select *B*, *D*, or *F*.

TASK 5 (Objective 3): Tell the child that although an animal needs sharp teeth to crack a hard nut, strong jaws are also important. Explain that birds also need more than sharp pointed beaks to bore holes. Suggest that while moving his head in a pecking motion, the child put his hand on the back of his neck to feel his muscles pulling. This should suggest the need for strong neck muscles. Point this out if necessary. Ask the child to look at the birds again. Ask, **Do you want to change any of your inferences about which birds could make the holes?** The child should change his first inference, or make a statement in support of his first inference, such as "The birds in pictures *B* and *D* have thick necks as well as pointed beaks," or "It couldn't be the bird in picture *F* because its neck looks too weak."

Materials

Picture card, 1, footprint, Figure 6 (*Module 46*)
Woodland Scene, 1 wall chart (*Module 46*)
Picture card, 1, birds' heads (*Module 46*)

FIGURE 6

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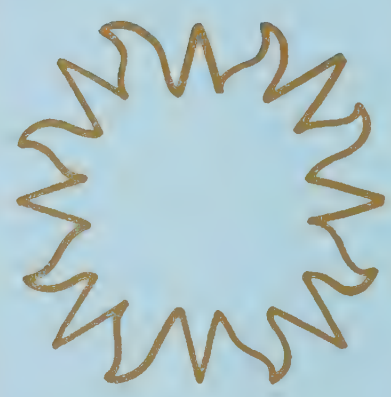
Printed in the United States of America

46 Inferring/c

SCIENCE...



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SCIENCE... A PROCESS APPROACH II

MODULE

47

Communicating/f and g

Scale Drawings
A Tree Diary

OBJECTIVES: Scale Drawings (Communicating/f)

At the end of this module the child should be able to

1. *DISTINGUISH* between representations of objects that are life-size and those that are not.
2. *DESCRIBE* the relationship between the actual size of an object and its representation when the scale is given.
3. *DEMONSTRATE* a procedure for drawing an object to a given scale.

OBJECTIVES: A Tree Diary (Communicating/g)

At the end of this module the child should be able to

1. *IDENTIFY* changes in a selected tree from observations made over a period of several months.
2. *CONSTRUCT* inferences about changes observed.
3. *DESCRIBE* the tree as a whole and with reference to its parts, including changes in the tree and its parts over several months.

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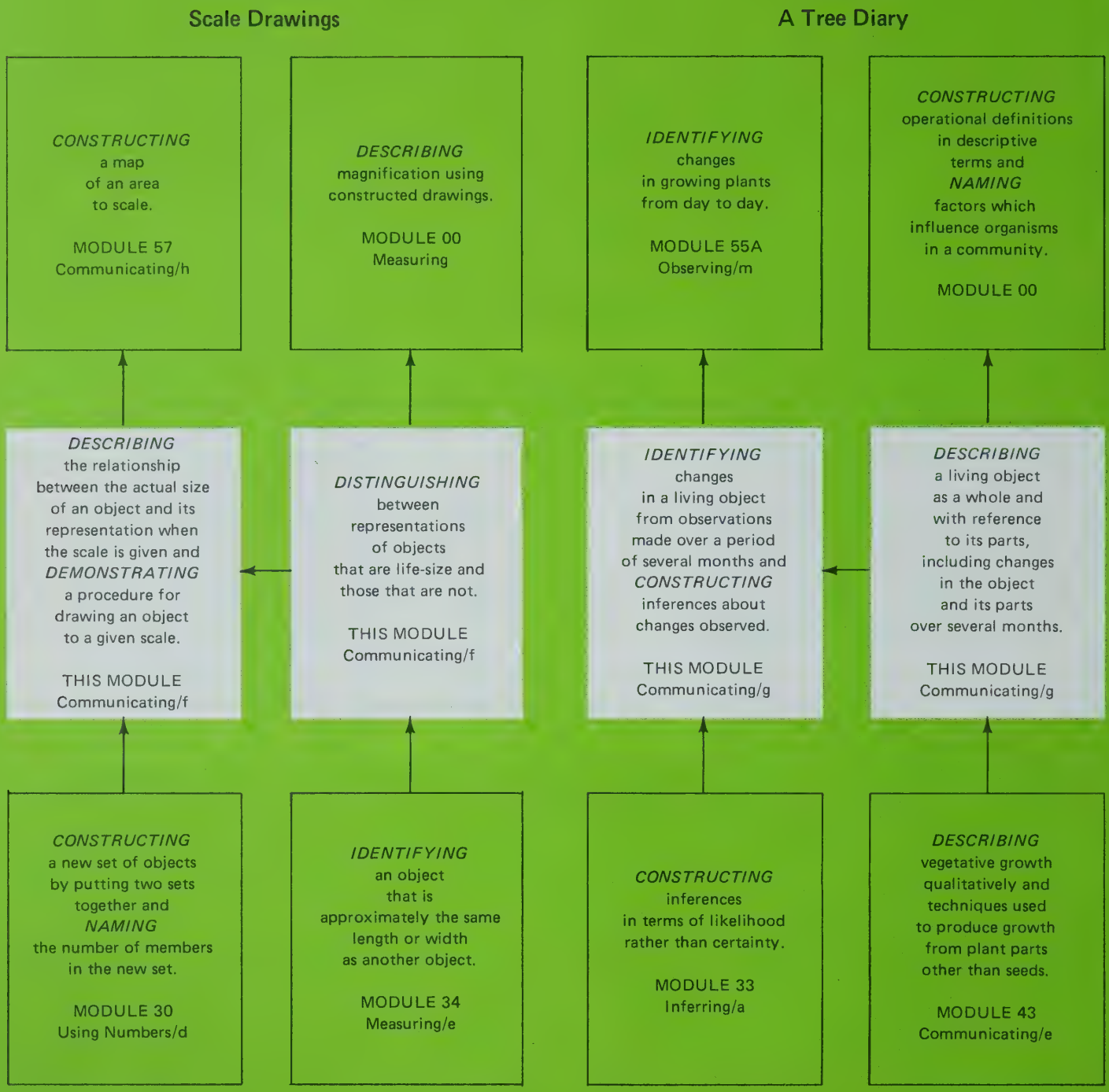
SEQUENCE


Scale Drawings
A Tree Diary
CONSTRUCTING a map of an area to scale. MODULE 57 Communicating/h
DESCRIBING magnification using constructed drawings. MODULE 00 Measuring
IDENTIFYING changes in growing plants from day to day. MODULE 55A Observing/m
CONSTRUCTING operational definitions in descriptive terms and NAMING factors which influence organisms in a community. MODULE 00
DESCRIBING the relationship between the actual size of an object and its representation when the scale is given and DEMONSTRATING a procedure for drawing an object to a given scale. THIS MODULE Communicating/f
DISTINGUISHING between representations of objects that are life-size and those that are not. THIS MODULE Communicating/f
IDENTIFYING changes in a living object from observations made over a period of several months and CONSTRUCTING inferences about changes observed. THIS MODULE Communicating/g
DESCRIBING a living object as a whole and with reference to its parts, including changes in the object and its parts over several months. THIS MODULE Communicating/g
CONSTRUCTING a new set of objects by putting two sets together and NAMING the number of members in the new set. MODULE 30 Using Numbers/d
IDENTIFYING an object that is approximately the same length or width as another object. MODULE 34 Measuring/e
CONSTRUCTING inferences in terms of likelihood rather than certainty. MODULE 33 Inferring/a
DESCRIBING vegetative growth qualitatively and techniques used to produce growth from plant parts other than seeds. MODULE 43 Communicating/e

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

This module has two parts, *Scale Drawings* and *A Tree Diary*, each with its own set of objectives. Although the two sections contain different kinds of activities, they both emphasize the same process—communicating. In the first part, the children learn one way to communicate the size of an object, and in the second part, they have an opportunity to further develop skill in communicating observations.

During their study of scale drawings, the children learn that it is frequently not possible or desirable to draw objects to life size, and that drawing an object to scale is one way of communicating the actual size of the object. They learn that scale drawings show a ratio or fraction that indicates the relationship between the representation and the actual dimensions of the object. For example, if the scale of a drawing is 1:4 or 1/4, the size of the drawing is one-fourth the size of the actual object, and the length of any part of the drawing can be multiplied by four to calculate the length of that part of the actual object. Similarly, if the scale of a drawing is 2/1, the drawing is twice the size of the actual object, and the length of any part of the object is 1/2 the length of that same part of the drawing. As children mature, their learning progresses from direct, concrete experiences to representations of these experiences in symbols and drawings. Drawings can give children much information regarding the characteristics of specific objects; if the drawings are made to scale, they can also help a child to visualize objects in their correct dimensions.

As the children record their observations in the tree diaries, they gain experience in precise communication using words and pictures. The diary is an auto-instructional activity that will be utilized best if the child begins it in September and works on it from time to time throughout the year. Those children who complete the diary will have recorded what happened to a tree that they choose to study over the course of a school year. Earlier in *Science . . . A Process Approach* the children may have studied *Trees in Our Environment, Classifying c, Module 16*; in that module, each child selected a tree for observation. In this module a more mature exploration is required of the child. Over a period of several months, the children observe the tree and its growth, and note some organisms that are associated with the tree. Attention is drawn to changes observed from month to month, and from season to season. The preparation of the diary gives the children a chance to work on their own, at their own rate, on activities that they themselves select.

Vocabulary

scale	realistic	needle	bud
life-size	*Diplodocus*	thorn	fruit
linear-measurement		*Stegosaurus*	

INSTRUCTIONAL PROCEDURE

Scale Drawings

Introduction

Give the children various drawing materials and paper, and ask them to draw as realistically as possible one of several large objects with straight, parallel sides. You might suggest, for example, a table, a file cabinet, a facial-tissue box, or a bookshelf. When the children are finished, display several of their drawings, and compare these drawings with the real objects. Discuss such characteristics of the drawings as the view shown and the amount of detail represented. If the children do not make any observations about size, ask them if their drawings show the real size of the objects. (The drawings will probably be smaller than the objects.) Ask the children for ideas about how the sizes of the objects might somehow be indicated. Save the drawings and tell the children that when they find a way to represent size, they will be able to indicate size in future drawings.

Materials

Drawing paper, several sheets for each child
Pencils or crayons, 1 for each child

Activity 1

Refer to the drawings of objects the children made previously. Ask the children if they could show the size of the objects more realistically if they were to draw them again. The children will probably say they could draw the objects life-size if they had big enough pieces of paper. Ask if it is always possible to draw a life-size picture of something—of a very large animal such as an elephant, for example. If some children wish to attempt to make a life-size drawing of a large animal, provide large sheets of drawing paper or newsprint, and encourage them to try.

Next, continue the discussion by mentioning dinosaurs, and by asking whether the children could draw life-size pictures of these animals. Tell the children that *Diplodocus* (dĭ–plŏd′–ə–kəs) was a dinosaur; then ask the children how they might tell someone about the size of

a dinosaur such as *Diplodocus.* Then give each child a drawing of *Diplodocus* (see Figure 1). Ask the children if the person who drew this dinosaur has told us something about its size. Direct their attention to the label *Scale, 1/100* if no one has noticed it, and ask what it could mean.

Ask what the *1* might refer to. You may have to tell the children that the numeral *1* refers to the unit of length in the drawing—specifically, one centimeter. The children may guess that the 100 refers to the corresponding units of length—that is, 100 centimeters—on a real *Diplodocus.* Explain that if the drawing were made one hundred times longer and one hundred times taller, it would represent the length and height of a real *Diplodocus.*

Tell the children that there is a word to describe the numerals and what they are supposed to communicate, and that this word is *scale.* The *Diplodocus* is drawn to the scale of 1/100 (one to one hundred). Scale drawings are one way of indicating the true size of the dinosaur, and the specific scale of 1/100 tells us that every centimeter on the drawing represents 100 centimeters on the real dinosaur.

Point out that the foot of a real *Diplodocus* was really one hundred times as wide as the foot on the drawing, and the dinosaur was one hundred times as long and one hundred times as tall as shown on the drawing. In the drawing the length dimension measures about 18 centimeters. (*Diplodocus* is shown with his head up and his tail somewhat curled, so the length measurement does not represent the longest possible dimension.) One hundred times this number is 1800 centimeters, or 18 meters.

Have the children measure various parts—head, tail, and so on—of *Diplodocus* on their scale drawings. Then have the children work as a group, with your assistance when necessary, to calculate the dimensions of these parts of the real dinosaur. The children may enjoy drawing parts of *Diplodocus* full size on paper or on the chalkboard.

Materials

Drawing paper or newsprint, for life-size drawings (optional)
Diplodocus, 1 spirit master, Figure 1 (*Module 47*)
Metric rulers, 30, (*Module 47*)

Activity 2

Give each child a copy of the scale drawings of a horse, a dog, and a mouse. (See Figure 2.) Ask the children if the pictures are about the same size. (Yes.) Then ask the children questions such as these: Are these animals actually the same size? (No.) If you had never seen these animals before, how could you use the drawings to tell how tall and how long each animal really is? Discuss the use of the scale numerals 1/20, 1/10, and 2/1 to make sure that each child understands what they mean.

Ask the children how they could find out how long the horse's right front leg really is. To do this, they should measure the horse's leg on the drawing and multiply by the number indicated in the scale—20, in this case. If the children have difficulty multiplying, they might find the measurement by repeated addition. Remind them that if

FIGURE 1

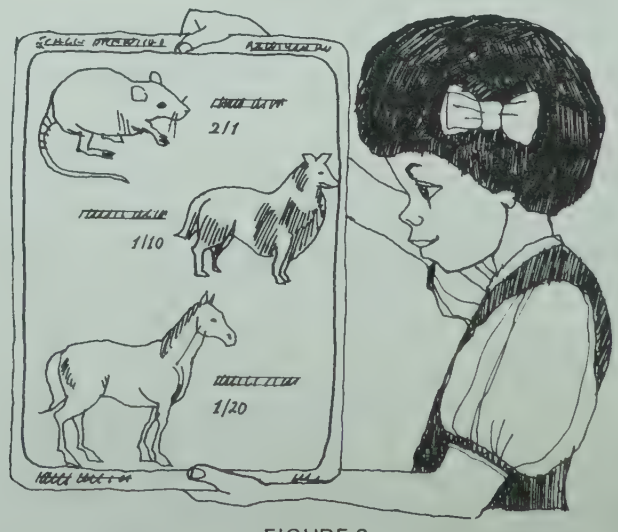

FIGURE 2

the scale is 1/20 every centimeter length on the drawing is the same as 20 centimeters on the actual horse.

Give the children sheets of paper and ask them to list on it the parts of the horse, dog, and mouse they would like to measure on the drawings. Their lists might look like Figure 3. Give the children metric rulers and ask them to make the measurements they have listed.

Now ask the children to calculate the *real* lengths for parts of the horse, the dog, and the mouse, either by multiplication or by repeated addition. You may want to have the group work together on one or two calculations and then have each child complete his own. Suggest that the children draw line segments to indicate the actual lengths of the parts measured.

Materials

Scale Drawings, 1 spirit master, Figure 2 (*Module 47*)
Writing paper, 1 sheet for each child
Metric rulers, 30 (*Module 47*)

	Lengths on Drawing	Real Lengths
HORSE		
width of neck:	____ cm	____ cm
length of foreleg:	____ cm	____ cm
DOG		
length of tail:	____ cm	____ cm
length of head:	____ cm	____ cm
MOUSE		
length of foot:	____ cm	____ cm
width of ear:	____ cm	____ cm

FIGURE 3

Activity 3

Ask each child to make a drawing of a small object such as a book, chalkboard eraser, brick, or block to a scale of 1/2. If necessary, help the children by reminding them that if the scale is 1/2, every 2 centimeters of length on the object will correspond to 1 centimeter on their drawings. Ask the children how long a line they would draw to represent a length of 10 centimeters on the object; they should answer that this line would be 5 centimeters. To simplify their calculations, you may want to suggest that the children round off their measurements of the object to the nearest centimeter.

Next suggest that the children make scale drawings of the objects they drew for the *Introduction.* Let the children select their own scales. When they have completed their drawings, the children might like to tape them to the object and discuss the relationship between the size of the drawing and the size of the object.

Ask pairs of children to exchange drawings and let each child use the drawing he was given to determine the length and width of the actual object. If, after measuring the real object, a discrepancy exists, have the child who is interpreting the drawing meet with the child who made the drawing to determine who made the error and to correct it. Children who are having difficulty understanding scale might be paired with children who are having no trouble with the concept. Oftentimes a pupil can be helpful in clearing up another pupil's problem.

Materials

Drawing paper, 1 sheet for each child
Pencils or crayons, 1 for each child
Small rectangular objects, several, such as books, chalkboard erasers, bricks
Metric rulers, 30 (*Module 47*)

Generalizing Experience

Have the children find in books, dictionaries, or encyclopedias drawings made to scale that show the scale representation clearly. Maps are especially good for this purpose. Ask the children to indicate an approximate idea of the actual size of the illustrated objects. These drawings might be contrasted with other drawings that are *not* drawn to scale. Then the uses and values of each style of illustration might be discussed.

Materials

Scale drawings, several, in books, encyclopedias, dictionaries, or other sources
Pictures, several, *not* drawn to scale

INSTRUCTIONAL PROCEDURE

A Tree Diary

Introduction

This section of the module is an individual activity and is almost completely auto-instructional. Give the child the sheets that make up the *Tree Diary.* The child might keep these sheets in a folder or binder, or may choose to paste them into a spiral notebook. Although the child should work independently, you might discuss his or her questions and comments from time to time. Emphasize that in this activity, the child is to communicate by written words and drawings. Two children can work together if they wish, but each child should produce his or her own diary.

Before the children begin to keep their diaries, you should briefly discuss the project with them. It is not necessary to provide for discussion of results or progress; however, if you wish, a little time might be devoted at the end of each month to an exchange of ideas among the children who are keeping diaries.

Materials

Tree Diary, 8 spirit masters (*Module 47*)

Generalizing Experience

The preparation of the tree diary is in itself a generalizing experience. The child who carefully prepares a comprehensive report of information collected over a period of months will have made use of science process skills and will have applied them to tasks in other disciplines. Indeed, the preparation of the diary should be considered by the teacher and child to be contributing to science, language, and art experiences.

The children might visit a tree near a factory or other source of pollution and then add a supplement to their diaries about the effect of pollution on that tree, or they may prepare a diary about the change in a stream or pond over a period of time.

Flying Squirrel

FIGURE 4

APPRAISAL: Scale Drawings

Divide children into groups of about six. Give each child a copy of *Stegosaurus* marked with the scale 1/40.

Ask the children what this picture shows about the actual size of the animal. Accept any answer that indicates that it was forty times longer or taller than pictured.

Tell one group of children that you would like to know how wide (in centimeters) the left back knee of the reptile really was. Point out this dimension or any other that you may want to substitute. Ask the children to work together or individually, as they wish. You may need to help with the multiplying. When the children have made the measurement and converted it, using the scale, ask them to draw a line of the actual length on the chalkboard. Ask other groups to find dimensions of other parts of the reptile and to report in a similar fashion.

Materials

Stegosaurus, 1 spirit master (*Module 47*)
Metric rulers, 30 (*Module 47*)

COMPETENCY MEASURE: Scale Drawings

TASK 1 (Objective 1): Show the child the picture card of a flying squirrel (see Figure 4). Ask, Does this drawing show us the actual size of the squirrel? The child should respond "No" or "I do not know."

TASK 2 (Objective 2): Now write *Scale, 1/2* on a piece of paper and place it on the drawing. Ask the child, What do these numerals mean? The child should explain in some way that the animal is twice as large as pictured.

TASK 3 (Objective 2): Give the child paper, pencil, and a metric ruler in addition to the picture card of the squirrel. Say, Measure the length of the drawing of the squirrel's tail to the nearest centimeter and then tell me how long the squirrel's tail really is. The child should multiply his measurement by 2. Disregard any errors the child makes in multiplication or in measuring.

TASK 4 (Objective 3): Give the child a crayon. Say, Using a scale of 1/1, draw a picture of this crayon. The child should measure the length and the width of the crayon with the ruler, draw lines on the paper as long as the measurements and then add enough detail to suggest the shape of the crayon. Or the child might trace around the crayon.

Materials

Picture card, 1, of a flying squirrel, *(Module 47)*
Drawing paper, 2 sheets for each child
Pencil, 1 for each child
Metric rulers, 30 (*Module 47*)
Crayon, 1 for each child

APPRAISAL: A Tree Diary

There is no specific *Appraisal* for this activity. The *Competency Measure* will serve as the appraisal for an individual who has prepared a diary, or for two children who worked together to produce their own diaries.

The learning that takes place while the child keeps the *Tree Diary* occurs at least as much in the affective as in the cognitive domain. Therefore, the results of the *Competency Measure* that follows can only be a partial indication of the learning that the child has experienced. If the child continues to keep the tree diary independently, it is a good indication that the child has enjoyed the experience and has become interested in observing and communicating about naturally occurring changes.

COMPETENCY MEASURE: A Tree Diary

TASK 1 (Objective 1): Say to the child, Tell me three observations about how the tree changed from September to May. The child should name three observed changes such as the following: the leaves changed in color, the leaves fell in the fall, the tree had blossoms on it in the spring, the tree grew taller.

TASK 2 (Objective 2): Say, Tell me what you think caused _____ (select the change mentioned by the child about which you think he or she can make a reasonable inference.) The child should state a reasonable inference.

TASK 3 (Objective 3): Say, You have written a diary about a tree. Tell me in your own words what you think are the most interesting things about the tree. Be sure to tell me something about the parts of the tree, too. The child should talk about the tree and its parts.

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47 Communicating/f,g

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SCIENCE... A PROCESS APPROACH II

MODULE
48

Predicting/c

The Bouncing Ball

OBJECTIVES

At the end of this module the child should be able to

1. *CONSTRUCT* a bar graph to show the relationship between two variables.
2. *CONSTRUCT* predictions by interpolating on a graph.
3. *DEMONSTRATE* a test of a constructed prediction.

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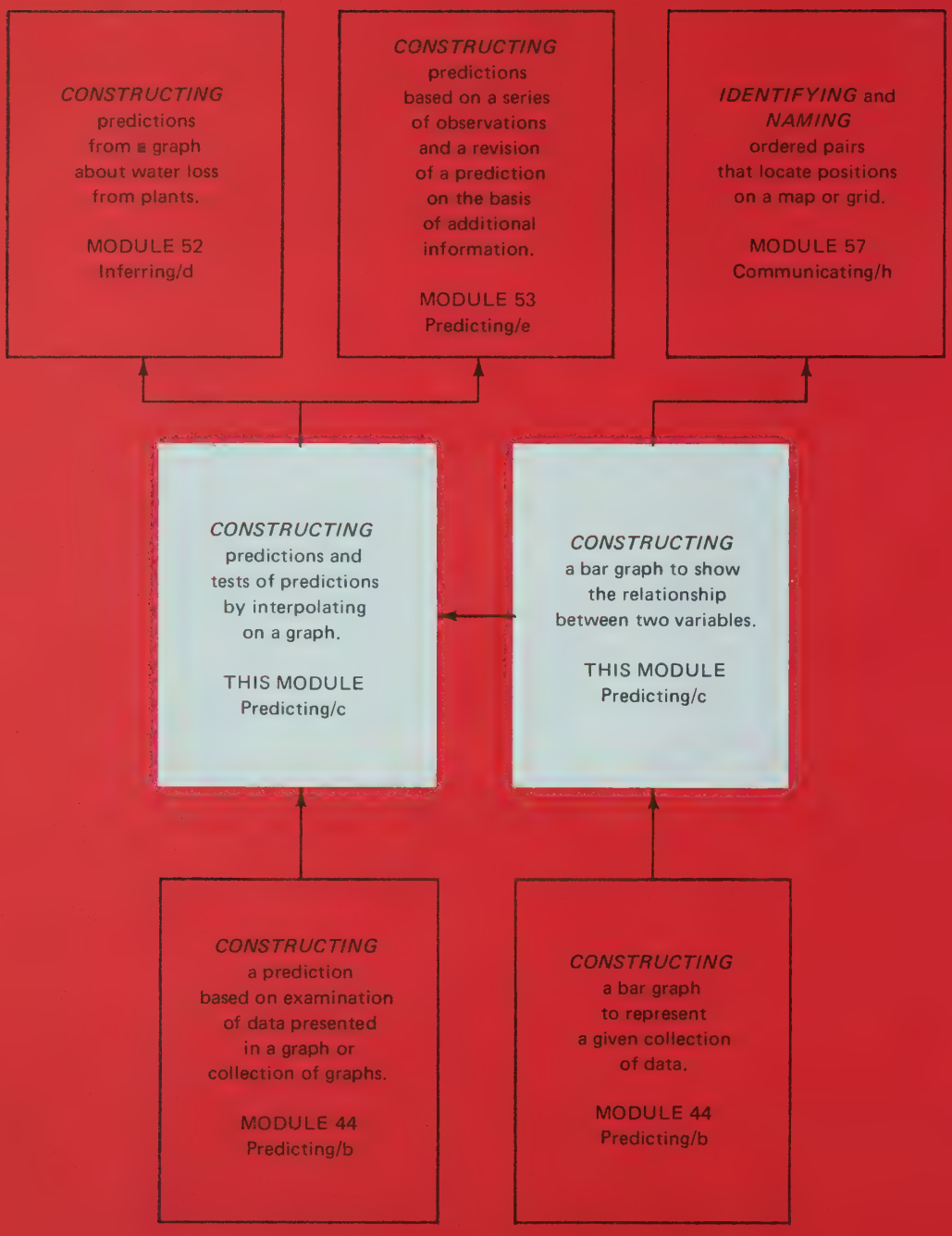
SEQUENCE


CONSTRUCTING predictions from a graph about water loss from plants.
MODULE 52 Inferring/d
CONSTRUCTING predictions based on a series of observations and a revision of a prediction on the basis of additional information.
MODULE 53 Predicting/e
IDENTIFYING and *NAMING* ordered pairs that locate positions on a map or grid.
MODULE 57 Communicating/h
CONSTRUCTING predictions and tests of predictions by interpolating on a graph.
THIS MODULE Predicting/c
CONSTRUCTING a bar graph to show the relationship between two variables.
THIS MODULE Predicting/c
CONSTRUCTING a prediction based on examination of data presented in a graph or collection of graphs.
MODULE 44 Predicting/b
CONSTRUCTING a bar graph to represent a given collection of data.
MODULE 44 Predicting/b

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

In this module, the children gain further experience in using graphs to record and communicate experimental data. In *Using Graphs, Predicting a, Module 38,* the children learned how to make predictions of values *beyond* the data recorded on a graph (extrapolation). In the present module, the children use graphs for predicting values *between* recorded data (*interpolation*). The children will use this skill repeatedly in their study of both science and mathematics.

In earlier modules, the children worked with stationary or slowly moving objects, which afforded easily observable relationships. This module provides an introductory experience in observing and describing objects that are moving rapidly. The children begin to realize the difficulty in making observations of rapid motions with the eye alone.

The children collect and graph data on the bounce heights of different kinds of balls when the balls are dropped from various heights. Observing the different bounce heights may lead the children to ask what causes the differences. The explanations are complex, involving the elasticity of both the balls used and the surfaces on which they are bounced. You might mention these factors if the question arises, but you need not introduce technical considerations at this level.

This module is well adapted to work in small groups, in which individuals help each other and rotate the various tasks to be done; for example, each member of a team should have a turn at dropping the ball. Let the teams work with as few directions from you as possible.

If any of the children have not constructed graphs before, or if you feel a review is needed, present either *Introduction to Graphing, Communicating b, Module 25,* or *Using Graphs, Predicting a, Module 38.*

Vocabulary

bounce	pattern
release	predict
height	

INSTRUCTIONAL PROCEDURE

Introduction

Divide the children into groups of four. Give each group a sponge-rubber ball and have each group appoint a "ball dropper." The ball dropper will drop the ball and catch it as it bounces back. Have each group do this once and then report their observations. Descriptions should include the appearance of the ball, its straight line motion toward the floor and back, the blurry appearance of the ball while it is in motion, and the sound it makes when it bounces.

Next, ask each group to appoint a new ball dropper and also a bounce-height spotter, a recorder, and a starter. Explain that this time the important observation is the height of the first bounce after the ball is dropped. The ball dropper will drop the ball as before. The starter in the group can mark the position of the ball before it is dropped by holding his or her hand out at the level of the ball. By the same method, the bounce-height spotter is to mark the height to which the ball bounces. The recorder is to measure the height of the ball before dropping and the height of the bounce, and record both heights on the chalkboard. (See Figure 1.) Ask the children why the heights of the bounces recorded by the groups are different.

FIGURE 1

Their responses might include the following ideas:

The ball droppers dropped the balls from different heights.

The bounce-height spotters could not tell exactly where the highest points were.

The floor was different in various places in the room.

Materials

Sponge-rubber balls, 7-8 (*Module 48*)
Metersticks, 7-8 (*Module 48*)

Activity 1

Prepare three or four wall charts like the one described here. On shelf paper or sheets of newsprint draw a series of six horizontal lines 2 decimeters apart. Draw the first line 2 decimeters from the bottom of the paper. Label the lines from 2 to 12. Put the zero line of the scale along the bottom edge. (See Figure 2.) Use masking tape to attach the paper to the wall with the bottom edge of the paper at floor level.

Set up three or four stations in the room, in the hall, or in the gymnasium where charts can be mounted. These stations should have hard, level floors. In some schools, outside corridors can be used.

Ask the children if the spaces between the lines on the chart seem equal. If there is any question about this, ask one child to measure the spaces.

Show the children what they will be doing later in small groups. Have one child hold the sponge-rubber ball at the 12-decimeter line and drop it without any pushing or throwing motion. Ask the children how high the ball went on the first bounce. Have the child drop the ball again, if necessary. Now have another child drop the ball from the 8-decimeter line. How high was the first bounce this time? Discuss with the children the difficulty of determining the height of a ball's bounce.

Have all the children estimate the height of the first bounce several times. Then have them compare their estimates. Do they always agree? They will discover that their eyes should be at about the level of the high point of the bounce and that they can read the height on the chart more easily if the ball is bounced close to the paper.

Divide the children into groups of three or four. At some time during the day, have each group go to one of the stations. Each group should be equipped with a sponge-rubber ball, a hard rubber ball, and a table-tennis ball, as well as pencils, paper, and a copy of *Bouncing Balls* for recording their data in graphic form. Have the groups drop each ball from the 4-, 8-, and 12-decimeter lines and record the bounce-heights. Have them repeat each of their trials at least once.

In a group of three, one child might drop a sponge-rubber ball from each height while the other two watch the bounce height and record it. The group may want to have one member mark the chart with his finger until the recorder decides what number to write. Another child might then make the series of drops with a hard rubber ball, and so on. Ask the children to be prepared to explain any erratic behavior of the balls. Have each group agree on a single set of data for the three drop-heights for each of the balls. Each group member should have a copy of the agreed upon data.

Materials

Shelf paper or several sheets of newsprint to make a wall chart about 7.5 dm wide by 1.5 m long
Meterstick, 1 (*Module 48*)
Marking pen, 1
Masking tape, 1 roll, to hang wall charts
Sponge-rubber balls, 4 (*Module 48*)
Hard rubber balls, 4 (*Module 48*)
Table-tennis balls, 4 (*Module 48*)
Bouncing Balls, 1 spirit master (*Module 48*)
Writing paper, 1 sheet for each child
Pencils, 1 for each child

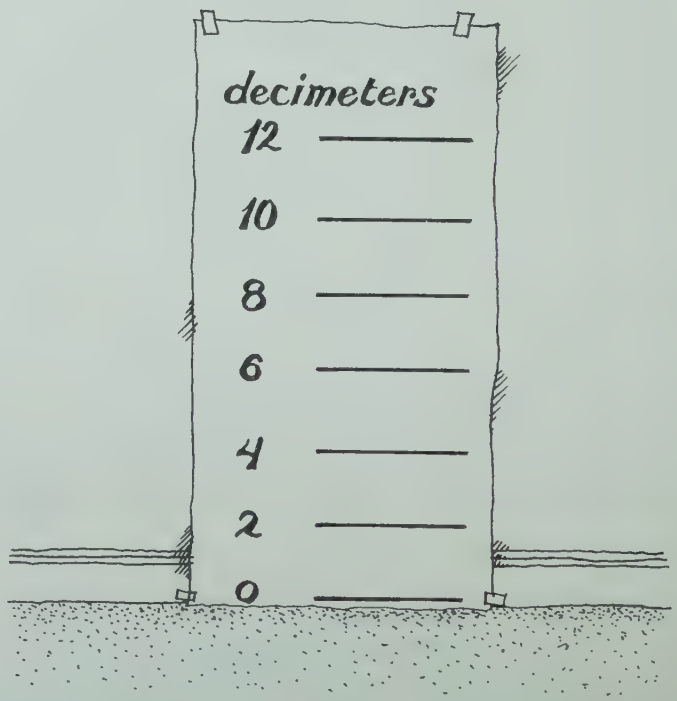

FIGURE 2

Activity 2

Ask the children if they see a pattern in the data they collected during the previous activity. Also ask what would help them see such a pattern. Ask if it would help to graph the data.

Ask a child from one of the groups to write that group's data for the sponge-rubber ball on the chalkboard. The data might be similar to the following.

SPONGE-RUBBER BALL	
Drop-height, in decimeters	Bounce-height, in decimeters
4	2
8	4
12	6

Use the group's data to construct a demonstration graph (Figure 3) on the chalkboard, or use an overhead projector. Emphasize the importance of giving the graph a title, labeling each axis, and marking the number lines along each axis.

Distribute graph paper and pencils, and have the children individually graph their group's data for the sponge-rubber ball. Ask the children if they see a pattern in their graphs. After all the children recognize the pattern, have them predict from their graphs what the bounce-heights would be for drops from the 6-decimeter line and from the 10-decimeter line. Have them mark their predictions lightly on their graphs and then return to the same stations to test their predictions with the sponge-rubber ball. When they have all done this, discuss the results.

Ask the children to graph the data collected for the hard rubber ball and for the table-tennis ball, and observe the pattern for each. Again, have the children construct and test predictions for each of these balls for intermediate points.

Materials

Graph Paper, 1 spirit master (*Module 48*)
Transparency, 1, duplication of *Graph Paper* (*Module 48*)
Transparency marker, 1
Pencils, 1 for each child
Sponge-rubber balls, 4 (*Module 48*)
Hard rubber balls, 4 (*Module 48*)
Table-tennis balls, 4 (*Module 48*)

Activity 3

Add lines to the wall charts used in *Activity 1*, so that there is a line drawn and labeled at each decimeter.

Have pairs of children in turn drop a table-tennis ball, measure the bounce-height, and record the bounce-height on the chalkboard. The ball-dropper of the first pair should start with a drop-height well above the scale. You may wish to have the child stand on a chair for this drop. The exact drop-height is unimportant, as long as the bounce-height falls on the scale. Have the second ball-dropper drop the ball from the bounce-height of the first ball, while his partner observes and records the new bounce-height. Repeat this procedure, each time having the child drop the ball from the preceding bounce-height.

Have the children make bar graphs from the data recorded on the chalkboard; then ask them to describe what happened. The children should notice that the bars of the graph become progressively shorter. Some children may guess that this graph represents a bouncing ball when it is dropped and allowed to bounce freely.

Ask the children to use their bar graphs to predict the bounce-heights when the ball is dropped from intermediate points. To test their predictions, have the children drop the ball from the intermediate heights.

Materials

Meterstick, 1 (*Module 48*)
Marking pen, 1
Masking tape, 1 roll to hang wall charts
Table-tennis balls, 4 (*Module 48*)
Chair, 1 (optional)
Graph paper, 1 spirit master (*Module 48*)
Pencils, 1 for each child

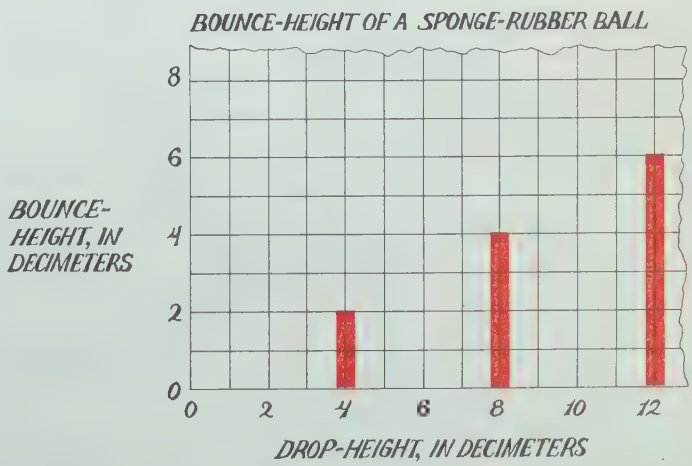

FIGURE 3

Generalizing Experience

Set up three stations so that each will accommodate one set of inclined planes and will provide enough space for five children to view the activity. At each station, place a set of inclined planes, a marble, a sheet of paper for recording data, several sheets of graph paper, and pencils.

Divide the children into groups of five and appoint a captain for each group. Then direct all the groups to the stations and explain the items there so that all will understand the procedure when their turn comes. Assign one group at a time to work at each station. Have pairs of children within each group take turns releasing the marble and noting the high point the marble reaches on the opposite plane. (See Figure 4.) Tell each group to release the marble from four release points, that is from the 4-, 6-, 9-, and 11-centimeter positions. One child of the pair should release the marble and the other should observe how far it rolls up the opposite plane. After each roll, have the captain of the group record the roll-distance and the corresponding release-point.

After the groups have collected and recorded the data for the four release-points, have each group construct a bar graph to describe their data, and then look for a pattern in the graph. Then have them predict roll-distances for intermediate release-points, and test their predictions.

Show the children how to change the height (elevation) of the planes. Have each group change the height of either or both planes, make new observations using the same release-points as before (4, 6, 9, and 11 centimeters). After the captains record the new data, ask each group to graph the data, make new predictions, and test their predictions.

Since the inclined planes may differ slightly, the data for each group of children may vary. Some children may want to examine several graphs to see if there is a pattern, or general relationship between release-points and roll-distances. If marbles of different sizes and weights are available, and if interest remains high, you might wish to encourage the groups to investigate how these new variables affect roll-distance.

Materials

Inclined planes, 3, Figure 4 (*Module 48*)
Marbles, 3 (*Module 48*)
Writing paper, 1 sheet for each group for recording "release points" and "roll points"
Pencils, 1 for each child
Graph paper, 1 spirit master (*Module 48*)
Marbles, several of different sizes and weights (optional)

FIGURE 4

APPRAISAL

Give the children graph paper, pencils, and the following data:

HOLLOW RUBBER BALL	
Drop-height, in decimeters	Bounce-height, in decimeters
14	7
10	5
6	3

Ask the children to graph the data. Then have them predict, by drawing the bars lightly on their graphs, the bounce-height if the drop-height is 12 decimeters. Now have them predict the bounce-height for a drop-height of 8 decimeters. Have the children select partners and test their predictions at one of the several stations previously set up for *Activities 1* and *3*. Since the hollow balls will be new to the children, encourage them to check the data you gave them. Those data may differ from the data the children collect because of floor composition, and so on. When the children have tested their predictions, collect all of the graphs and discuss them with the children.

Materials

Graph paper, 1 spirit master (*Module 48*)
Pencils, 1 for each child
Hollow rubber balls, 4 (*Module 48*)

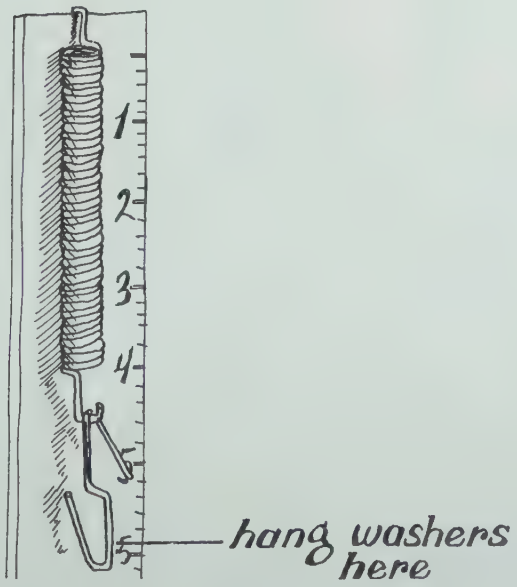

FIGURE 5

COMPETENCY MEASURE

Attach a large paper clip, bent to hold washers, to the bottom of a light-tension spring. Then attach the spring to the top of a meterstick with another bent paper clip. (See Figure 5.)

TASK 1 (Objective 1): Give the child a sheet of paper for recording data, a sheet of graph paper, and a pencil. Supporting the top end of the meterstick, stand it vertically on the floor or table. Say to the child, **I am going to attach a washer to the hook on the bottom of the spring. Write down the number of centimeters that the spring stretches.** Attach the washer and wait for the child to record the result on the sheet of paper. Repeat this procedure for 2, 3, and 5 washers. Then say, **Make a bar graph to show how much the spring stretched as each washer was put in place.** The child should construct the graph and label the axes. You may remind him to label the axes if he forgets to do this. If the child cannot construct the graph, help him with it so that he can complete *Tasks 2* and *3*.

TASK 2 (Objective 2): After the graph is completed, say to the child, **Show on your graph how far you think the spring will stretch for 4 washers.** The child should draw a bar on the graph showing his prediction, which should lie somewhere between the recorded data for 3 and 5 washers. Do not require that the prediction be any more precise than this.

TASK 3 (Objective 3): Say, **Show me how you can test your prediction.** The child should add 4 washers (or take one off if 5 are already suspended) to the spring, read the amount the spring stretched, and compare the reading with what he predicted on his graph.

Materials

Paper clips, 2, large
Light-tension spring, 1 (*Module 48*)
Meterstick, 1 (*Module 48*)
Washers, 5 (*Module 48*)
Writing paper, 1 sheet for each child
Graph paper, 1 spirit master (*Module 48*)
Pencils, 1 for each child

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48 Predicting/c

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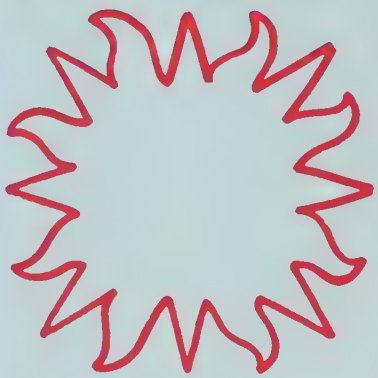

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SCIENCE... A PROCESS APPROACH II

MODULE

49

Measuring/i

Drop by Drop

OBJECTIVES

At the end of this module the child should be able to

1. *DEMONSTRATE* that a drop of liquid can be used as a unit of measure for finding the volumes of liquids.
2. *DEMONSTRATE* that drops of different liquids formed by droppers with openings of the same size may have different volumes.
3. *DEMONSTRATE* that drops of the same liquid formed by droppers with openings of different sizes have different volumes.

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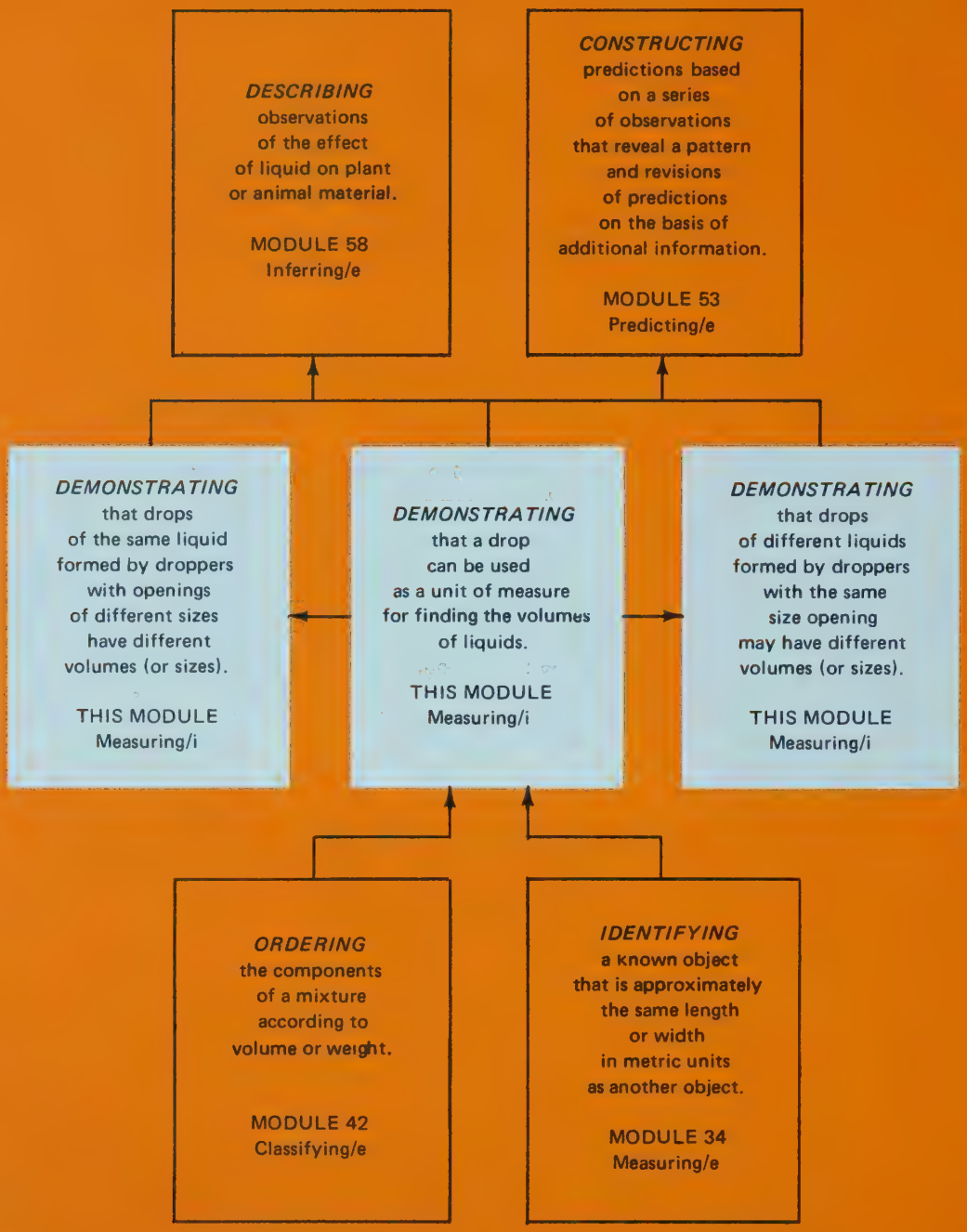
SEQUENCE


DESCRIBING observations of the effect of liquid on plant or animal material.
MODULE 58 Inferring/e
CONSTRUCTING predictions based on a series of observations that reveal a pattern and revisions of predictions on the basis of additional information.
MODULE 53 Predicting/e
DEMONSTRATING that drops of the same liquid formed by droppers with openings of different sizes have different volumes (or sizes).
THIS MODULE Measuring/i
DEMONSTRATING that a drop can be used as a unit of measure for finding the volumes of liquids.
THIS MODULE Measuring/i
DEMONSTRATING that drops of different liquids formed by droppers with the same size opening may have different volumes (or sizes).
THIS MODULE Measuring/i
ORDERING the components of a mixture according to volume or weight.
MODULE 42 Classifying/e
IDENTIFYING a known object that is approximately the same length or width in metric units as another object.
MODULE 34 Measuring/e

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

In this module children learn a method for measuring volumes by counting drops of liquid. In *Solids, Liquids, and Gases, Measuring g, Module 39,* the children measured the volume of water in standard units by using a graduated cylinder.

Children will learn that in using a drop as a unit of volume the size of the drop is influenced by the size of the opening in the dropper, by the presence of substances dissolved in the liquid, and by the kind of liquid. Drops from larger openings are larger than drops from smaller openings. From the same dropper, pure water forms larger drops than many other liquids—for example, alcohol and lighter fluid.

The surface tension of a liquid determines the size of a drop formed by the liquid: the greater the surface tension, the larger the drop. Adding certain substances to water can change the surface tension and thereby change the size of the drop. It is not intended however, that you introduce the children to the idea of surface tension in this module.

After doing *Activity 3* or the *Generalizing Experience* some children may wonder if a drop of pure water is larger than a drop of colored water. The addition of food coloring does not have a noticeable effect on the size of water drops. Have the children compare the size of drops of pure water with drops of colored water.

Vocabulary

droppers
graduated cylinder
dissolve

INSTRUCTIONAL PROCEDURE

Introduction

Give each child a dropper and a container with 50 milliliters or so of water in it. Ask the children to see if after filling their droppers with water they can squeeze the dropper so that the water comes out in drops. Let them practice until they gain some skill at this.

Give each group of four or five children a container with diluted blue food coloring in it. Suggest that the children observe what happens when they put the colored solution a drop at a time into the water in their containers. It will be easier for the children to see the colored drops if they put the containers of water on sheets of white paper.

After a few minutes ask the children to describe what they observed. They will probably mention seeing moving streaks of color in the water as a drop falls. Some children may notice that occasionally a drop forms a colored ring as it strikes the bottom of the container.

Suggest that the children stir the water in their containers until it is uniformly colored. Then ask them to observe what happens when clear water is added a drop at a time to their containers. You will need to supply some clear water for rinsing the droppers, as well as for dropping into the colored water. After a few minutes ask the children to describe what they observed. They may be surprised to find that it is not as easy, and perhaps impossible, to see the clear water drop in the colored solution as it was to see the colored water drop in the clear solution.

Materials

Droppers, 30 (*Module 49*)
Containers, 30, 250-ml, clear plastic (*Module 49*)
Containers, 6, 30-ml, clear plastic (*Module 49*)
Food coloring, 1 container, blue (*Module 49*)
(Note: Diluted food coloring can be prepared by putting 10 ml of blue food coloring into 100 ml of water.)

Activity 1

Have the children work in pairs. Give each pair of children a graduated cylinder, a container of colored water and two droppers, one for each child. Have the children put a thin piece of masking tape on one side of each dropper. (See Figure 1.) Suggest that the children fill the dropper as full as they can by squeezing the bulb hard and releasing it. Have them mark the top of the water column by making a pencil line on the masking tape. Finally, ask them to squeeze the bulb gently and count the drops as the dropper empties. They will probably find that the dropper holds between 10 and 15 drops.

After the children have counted the number of drops, ask them to find out how many drops it takes to make 10 milliliters. Some children may find out by counting the drops it takes to fill the graduated cylinder to the 10-milliliter mark. Others may count the number of times they fill their droppers to the pencil line, and then multiply or add to calculate the number of drops in 10 milliliters. Have the children keep a record of how many drops of water they found in 10 milliliters.

After they have finished, have one child of each pair write their results on the chalkboard. When all the values are on the chalkboard ask the children to compare measurements. There will undoubtedly be a range of values, but most of them will probably cluster around a value of 200 drops in 10 milliliters. You might ask the children how many drops there are in 1 milliliter. (About 20 drops.)

Materials

Graduated cylinders, 15, 50-ml (*Module 49*)
Containers, 15, 250-ml, clear plastic (*Module 49*)
Food coloring, 1 container, blue (*Module 49*)
Droppers, 30 (*Module 49*)
Masking tape, 1 roll

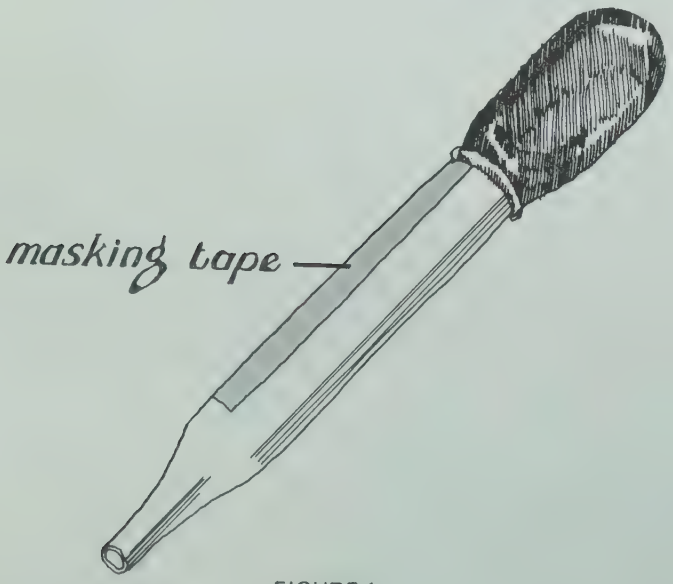

FIGURE 1

Activity 2

The droppers the children use in this activity have a larger opening than the droppers used in *Activity 1.* Begin by giving each pair of children a container of water colored with red food coloring, a graduated cylinder, and a dropper with a large opening (see *Materials*). Ask the children to find out how many drops of water fill the dropper to the line on the masking tape, and then to find out how many drops it takes to make 10 milliliters. You might begin by having them guess whether it will be the same number of drops as in *Activity 1.* Using the dropper with the larger opening, the children will find fewer drops in 10 milliliters than they found in *Activity 1.*

Before discussing the results, have some children write their data on the chalkboard. From a discussion of the results the children should agree that the number of drops per 10 milliliters or per dropper is less for the droppers with the larger openings. This means, of course, that large openings form large drops and small openings form small drops. The children should come to this conclusion on their own.

Materials

Containers, 15, 250-ml, clear plastic (*Module 49*)
Food coloring, 1 container, red (*Module 49*)
Graduated cylinders, 15, 50-ml (*Module 49*)
Droppers, 15 (*Module 49*)

(Note: Using a safety razor blade cut about 5 millimeters off the ends of the droppers, so that the opening is about twice as large as it was. See Figure 2.)

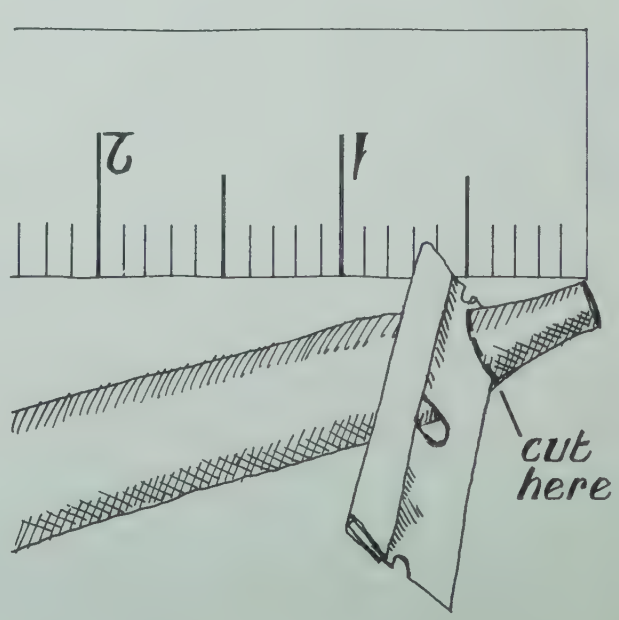

FIGURE 2

Activity 3 (Optional)

Another way to observe a difference in drop size is to examine the drops on surfaces, such as plastic food wrap, that do not absorb water. Have the children place a piece of plastic food wrap on a sheet of 2 millimeter graph paper and put drops of water colored with food coloring on the plastic. The sizes of the drops from droppers with different tip diameters can be compared by counting the number of squares of graph paper covered by each drop.

Materials

Droppers, 30, fifteen having larger openings and fifteen having smaller openings (*Module 49*)
Plastic food wrap, 1 piece for each child
Food coloring, 1 container, blue or red (*Module 49*)
Graph paper, 2mm, 1 sheet for each child
(Note: You may wish to make a copy of *Graph Paper* by using the spirit master (*Module 50*). Mark the copy with 2mm squares, and make copies of this sheet for the children.)

FIGURE 3

Activity 4

In this demonstration the children will see that drops of colored water are larger than drops of colored detergent solution. Set out two containers with about 10 milliliters of water in each. Add one milliliter of liquid detergent to one container of water. Color this solution with a drop or two of red food coloring and fill a dropper. Push the dropper through one of the holes in the square of cardboard (see *Materials*). Color the water in the other container with a drop or two of blue food coloring and fill another dropper that has an opening the same size as the first. Push this dropper through the second hole in the square of cardboard. Be careful that the detergent-dropper does not touch the water-dropper. Put the cardboard square with the droppers in place on the ring of the ring stand and set a container below the droppers. (See Figure 3.)

Turn an overhead projector on its side. Place the stand with the droppers and container between the translucent glass and the lens-mirror assembly so that a sharp image of the ends of the droppers is seen on a screen or light-colored wall. Rotate the cardboard so that the images of the droppers are well separated. (See Figure 4.) Focus by adjusting the lens-mirror assembly with the focusing knob.

Ask the children to watch the screen. Squeeze the bulb of the water-dropper slowly and carefully so that a single drop forms and falls off. The children's first reaction will probably be amusement. The drop on the screen falls up! Squeeze out a few more drops and ask the children to describe what they see. Now repeat this with the detergent-dropper. If the children do not compare the size of the

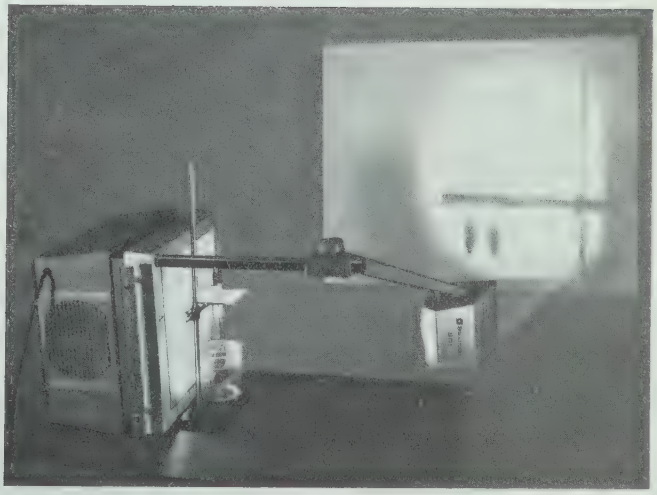

FIGURE 4

drop from one dropper with the drop from the other, have them watch while you squeeze both droppers at the same time. It takes a little practice to squeeze the two bulbs so that both drops fall together. You will find this easier to do if you watch the droppers instead of the screen. After the children have noticed that the red (detergent) drops are smaller than the blue (water) drops, have them guess why this is so. If a child suggests that the openings are a different size, say that both openings are the same size. If someone suggests that the color may influence the size, repeat the demonstration with blue-colored water and red-colored detergent solution. Then the blue drops will be smaller than the red ones.

In addition to using the overhead projector as just described, you might have small groups of children investigate drop size using the equipment illustrated in Figure 3. One child could squeeze the droppers and the rest of the children in a group could observe the drops, noting which are the larger ones. A hand lens might be useful to them in making the observations.

After the demonstration and discussion, tell the children that one of the liquids was water and the other was water with liquid detergent in it. Suggest that they find out for themselves which was which. Give each child a dropper, a vial half full of water, and 5 or 10 milliliters of liquid detergent solution in another vial. Ask how they can use these materials to compare the drop size of the two liquids. Have them decide for themselves how to do this. You may need to help by suggesting that they fill the dropper with water to the pencil line on the masking tape, and count how many drops of water are formed when the water is squeezed out. Then they might repeat the procedure with the detergent solution. They should rinse the dropper before using it to count water drops again. If they work carefully, all the children should find that more detergent solution drops form than water drops. They should also notice that the detergent drops are smaller.

Materials

Cardboard, 1 piece, 10 x 10 cm
(Note: With a sharp pencil punch two holes in the cardboard near its center. The holes should be about 3 cm apart.)
Food coloring, 2 containers, one red and one blue
Detergent, 1 bottle
Ring stand, 1 (*Module 49*)
Overhead projector, 1
Screen, 1
Hand lens, 1 (*Module 52*)
Droppers, 30, fifteen having larger openings and fifteen having smaller openings (*Module 49*)
Vials, 60, 30-ml (*Module 49*)

Generalizing Experiences

Have the children investigate the effect on drop size of various substances dissolved in water. They might test common substances, such as sugar, salt, and soap. What is the biggest drop the children can make or find?

The children might count how many drops from a dripping faucet it takes to fill a graduated cylinder to the 10-milliliter mark.

Another question the children might investigate is whether the drop size of ice water is the same as the drop size of hot water.

Materials

Droppers, 30, fifteen having larger openings and fifteen having smaller openings (*Module 49*)
Sugar, 1 box
Salt, 1 container (*Module 58*)
Soap, 1 box
Graduated cylinders, 15, 50-ml (*Module 49*)

APPRAISAL

Give each pair of children two droppers with openings of different sizes, a graduated cylinder, and a vial half full of rubbing alcohol. Ask the children to show how droppers are used to measure the volume of alcohol by counting drops.

Provide vinegar or milk, or some other liquid that has not been used. Have each child determine the drop size of the liquid and compare it with the drop size of water.

Ask the children to find out whether the size of the drops of alcohol differs when droppers with openings of different sizes are used.

Materials

Droppers, 30, fifteen having larger openings and fifteen having smaller openings (*Module 49*)
Graduated cylinders, 15, 50-ml (*Module 49*)
Vials, 15, 30-ml (*Module 49*)
Rubbing alcohol, 1 bottle (*Module 49*)
Vinegar, 1 bottle, or milk

COMPETENCY MEASURE

Have available two droppers each of a different diameter, two graduated cylinders, a container of clear water, and a container with some diluted liquid starch (see *Materials*).

TASK 1 (Objective 1): Give the child the dropper with the smaller opening. Point to the container of diluted liquid starch and say, Demonstrate how many drops of this liquid there are in 5 milliliters. The child should state the number of drops after demonstrating an acceptable method, for example adding the liquid drop-by-drop to fill the graduated cylinder to the 5-milliliter mark.

TASK 2 (Objective 2): Show the child the container of clear water and the container of diluted liquid starch. Say, I think that 5 milliliters of each of these two liquids will contain the same number of drops if I use the same dropper in each case. Demonstrate whether my guess is right or wrong using the dropper with the smaller opening. The child should measure the number of drops in 5 milliliters of water, compare it with his answer for Task 1, report a difference, and say that you were wrong in your guess. Or, he may again count the number of drops in 5 milliliters of diluted liquid starch before making a comparison.

TASK 3 (Objective 3): Give the child the two droppers, the container of diluted liquid starch, and a graduated cylinder. Say, Show me whether the drops of liquid starch from these droppers are the same size or different sizes. The child should demonstrate an acceptable procedure to show that the drops from the dropper with the smaller diameter are smaller than those from the dropper with the larger diameter.

Materials

Droppers 2, one having a small opening and one having a larger opening (*Module 49*)
Graduated cylinders, 2, 50-ml (*Module 49*)
Containers, 2, 250-ml clear plastic (*Module 49*)
Liquid starch, 1 bottle

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49 Measuring/i

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MODULE

50

Predicting/d

The Clean-up Campaign

OBJECTIVES

At the end of this module the child should be able to

1. *CONSTRUCT* a bar graph showing the amount of litter, or solid waste, collected over a period of time.
2. *CONSTRUCT* a prediction based on data presented in a bar graph.
3. *CONSTRUCT* a test of a prediction based on data presented in a bar graph.

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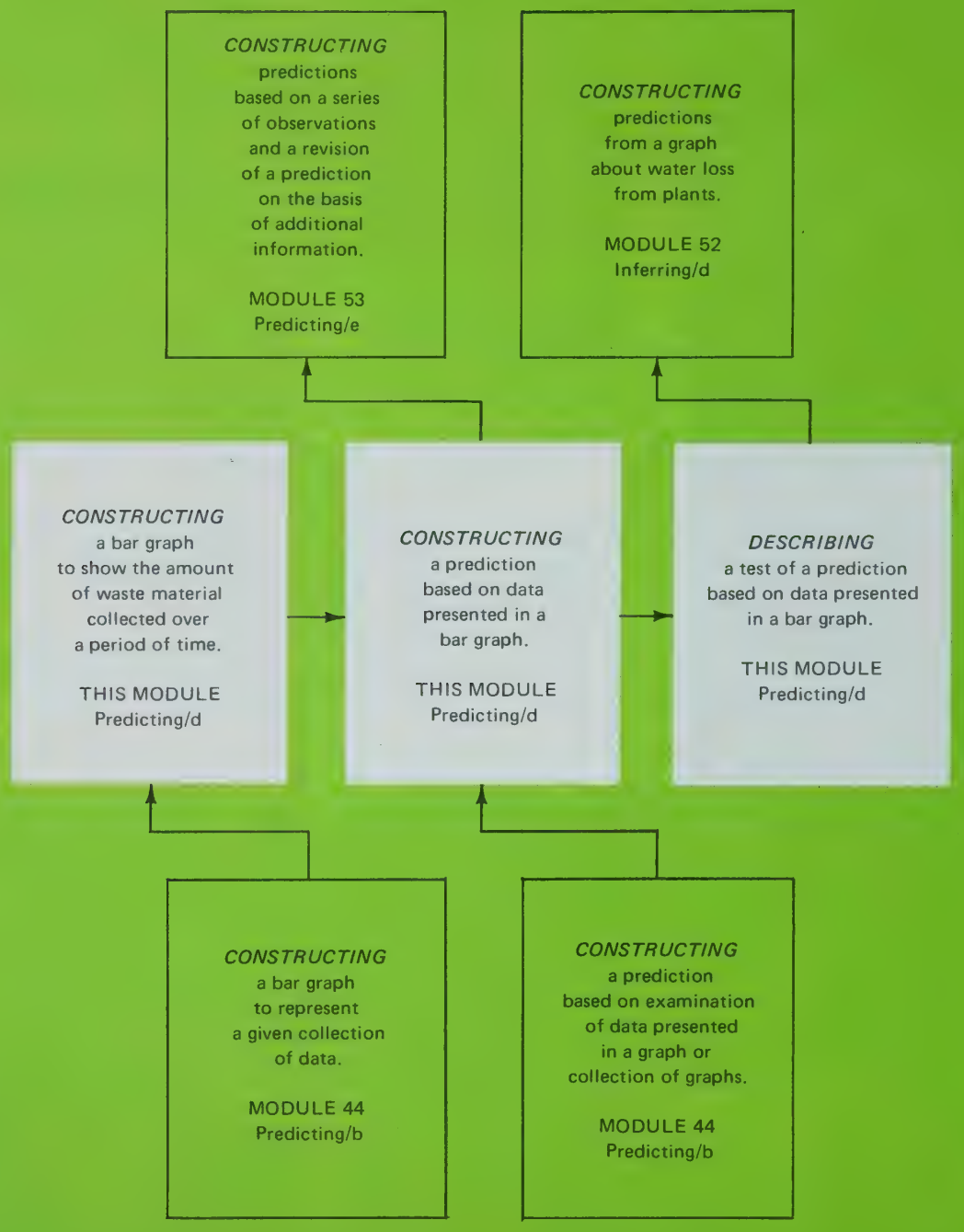
SEQUENCE


CONSTRUCTING predictions based on a series of observations and a revision of a prediction on the basis of additional information.
MODULE 53 Predicting/e
CONSTRUCTING predictions from a graph about water loss from plants.
MODULE 52 Inferring/d
CONSTRUCTING a bar graph to show the amount of waste material collected over a period of time.
THIS MODULE Predicting/d
CONSTRUCTING a prediction based on data presented in a bar graph.
THIS MODULE Predicting/d
DESCRIBING a test of a prediction based on data presented in a bar graph.
THIS MODULE Predicting/d
CONSTRUCTING a bar graph to represent a given collection of data.
MODULE 44 Predicting/b
CONSTRUCTING a prediction based on examination of data presented in a graph or collection of graphs.
MODULE 44 Predicting/b

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

In earlier modules, the children used graphs to record experimental data and to make predictions. In *Using Graphs, Predicting a, Module 38,* the children were introduced to the process of extrapolating, making predictions beyond observed data. In *The Bouncing Ball, Predicting c, Module 48,* the children made predictions by interpolating between observed measurements. In this module the children return to extrapolation to make predictions.

The *Introduction* and the first two activities provide the groundwork necessary for the clean-up campaign; the last two activities represent the campaign in action. Litter is collected from the designated area on the same day each week, sorted and counted, and the resulting data are graphed. The children make weekly visits to other rooms to keep the school informed of the campaign's progress.

While collecting data for the graphs, the children become aware of what is involved in helping to keep their immediate environment litter-free. If no containers are provided outside for litter, the children may be able to get a civic organization, the PTA, or a local business to donate them. It may be possible to expand the project to the entire community, or to correlate it with a city- or county-wide effort. It may also be possible to have the collected litter deposited in areas designated as collection centers for recycling. Many communities are working now to recycle paper, glass, aluminum, steel, and so on.

Vocabulary

litter	extrapolate
recycle	extrapolation

INSTRUCTIONAL PROCEDURE

Introduction

Take the children for a walk around the school grounds. Comment on the litter, and ask the children to notice the various types of litter, such as glass, paper, aluminum, and so on. Suggest that the children plan a campaign to eliminate the litter. Ask for suggestions about how this might be done and discuss the children's ideas. Try to incorporate as many of their ideas as possible into whatever plan is devised.

Activity 1

Designate an area for the clean-up campaign. Explain the importance of collecting litter in the same area for several weeks in order to find out if the amount of litter decreases during the campaign. Markers may be necessary to designate the area clearly.

Divide the children into groups of four and give each group a large paper shopping bag. You may assign a part of the area to each group, or have all of the groups clean up the entire area. Have the children collect all of the litter from the designated area. Be sure the children wear gloves if they collect broken glass.

After returning to the room, have each group sort the material they collected into piles of glass, paper, and so on. Have each group make a chart showing the number of items collected in each category. If the litter includes broken bottles, count several pieces as one bottle. You might suggest that the children make a chart like the one in Figure 1. When the groups have completed their chart, make a composite chart on the chalkboard for all groups (see Figure 2). Suggest that the children graph the results using the data from the chalkboard.

Suggest that the children also graph the data on a large poster to show to other classes and to display near the entrance to the school. After each weekly litter collection from the designated area, the children could add the new data to the poster. The children might make and post a separate graph for each type of material (see Figure 3) and update it each week; or they might make and post a graph each week showing all material collected (see Figure 4), and place the graph beside the one from the previous week. The children will probably find extrapolation from the graphs easier if separate graphs are made for each type of material collected, as shown in Figure 3.

Materials

Area markers, several, such as sticks and stones (optional)
Paper shopping bags, 8, large (*Module 50*)
Gloves, 1 pair for each group, for handling broken glass (*Module 50*)
Writing paper, 1 sheet for each group
Pencils, 1 for each child
Graph Paper, 1 spirit master (*Module 50*)
Shelf paper or posterboard, for making graphs
Marking pen, 1, for making graphs

KIND OF MATERIAL	NUMBER OF ITEMS COLLECTED			
	Week 1	Week 2	Week 3	Week 4
paper				
glass				
cans				
other stuff				

FIGURE 1

GROUP	NUMBER OF ITEMS COLLECTED BY EACH GROUP			
	paper	glass	cans	other stuff
Group 1				
Group 2				
Group 3				
Total				

FIGURE 2

Activity 2

Arrange with other teachers for your children to visit their rooms to explain the clean-up campaign and to enlist the aid of the other children in preventing litter. Have the campaigners use the week's graph or graphs to illustrate their points. The campaigners should tell the other children that they will report back in a week with the results. Be sure the children visit as many rooms as possible, so that they can enlist total school cooperation.

Materials

Graph or graphs, prepared in *Activity 1*

Activity 3

One week after the initial collection, send the groups back to the same area to collect litter again. Have the children sort it, chart the results for each group, and then graph the new data. Have them compare the new data with that of Week 1. The children may wish to prepare a graph of the composite data for Week 1 and Week 2.

This activity should be repeated on the same day each week until the project is completed. By collecting at regular intervals, the children are controlling the time variable.

Materials

Paper bags, 8, large (*Module 50*)
Gloves, 1 pair for each group (*Module 50*)
Writing paper, 1 sheet for each group
Pencils, 1 for each child
Graphs prepared in *Activity 1*
Graph Paper, 1 spirit master (*Module 50*)

FIGURE 3

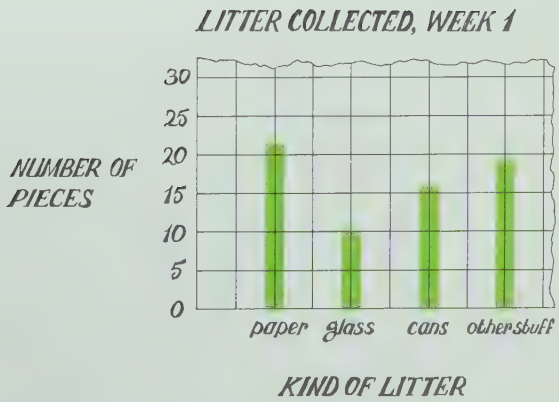

FIGURE 4

Activity 4

After collecting litter and graphing the data for two weeks, send the campaigners, armed with the graphs, back to the other rooms to report progress and to ask for continued support of the program.

Before they go to make their reports, you may wish to discuss with the children what they think next week's graph will look like. Ask them to make a prediction, using the data collected so far. You might also ask them how long it should take before there is *no* litter. Tell them that in both predictions, they are *extrapolating* from the information they have. Also mention that the more data they collect the better basis they will have for their predictions. Having made their predictions before visiting the other rooms, the children can then present and explain their predictions as part of the campaign. The next week's report will verify or refute their predictions.

Repeat *Activities 3* and *4* for several more weeks. Try to continue the campaign until litter is virtually eliminated from the school grounds.

Materials

Graphs, prepared in *Activity 3*

Generalizing Experience

Ask the children to name different things that can be counted and graphed. Give the children pencil and paper, and have them meet you on the playground (or some other safe place) to make a count of something they have suggested, or a count of the items in one of the lists below.

automobiles, station wagons, and other vehicles
solid-color automobiles (top and bottom of same color) and automobiles that are not solid-color
different colors of automobiles
men, women, and children
automobiles with driver only and automobiles with driver and passengers.

Divide the children into groups and have them share the responsibility for counting and recording.

After returning to the room, give each group a sheet of graph paper, and have each group use its data to prepare a bar graph. Make a composite chart on the chalkboard of the data from all of the groups. Have the children extrapolate to make a prediction about what they expect to see when they return for another count. Repeat the count at the same time of day on two more occasions. Each time, have the children add the new data to their graphs, predict, and test their predictions.

Materials

Writing paper, several sheets for each child
Pencils, 1 for each child
Graph Paper, 1 spirit master (*Module 50*)

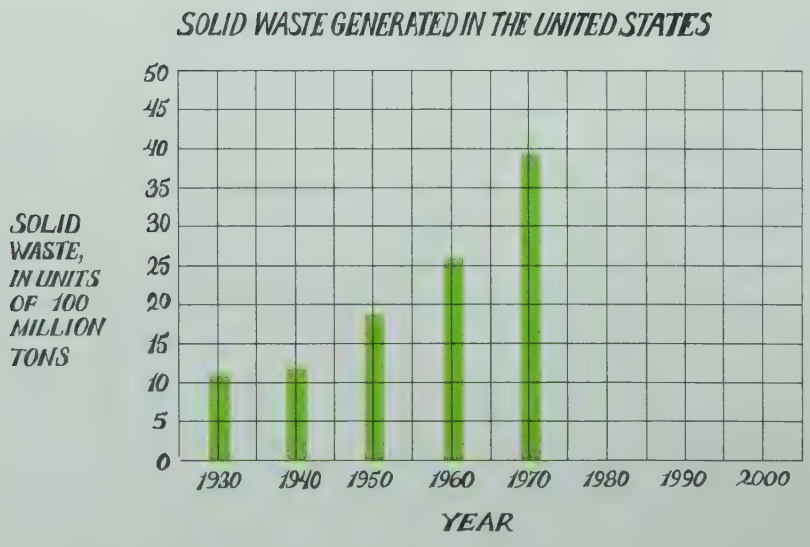

FIGURE 5

APPRAISAL

Give each child a pencil and a sheet of graph paper. List on the chalkboard the following data about solid wastes generated in the United States.

Year	Solid waste, in units*
1930	11
1940	12
1950	18
1960	26
1970	39

*One unit = 100 million tons.

Explain that solid wastes consist of garbage, cans, bottles, paper, automobiles, and so on.

Ask the children to construct bar graphs of the data. You may need to give them a little assistance in numbering the vertical scale and in drawing bars to the correct heights. The completed graphs should exhibit all of the major components shown in Figure 5.

After the children have constructed their graphs, ask them to predict the year in which 50 units of solid wastes will be generated in the United States. Predictions should be around 1975 to 1980. Ask the children to tell how they made their predictions from the graph.

Ask the children to describe a test of their predictions. Answers should suggest that recorded data be examined each year to compare them with the predicted values. The children might suggest that the data be collected and processed in essentially the same manner each year. Of course, it will be impossible for the children to demonstrate a test of their predictions.

Materials

Pencil, 1 for each child
Graph Paper, 1 spirit master (*Module 50*)

COMPETENCY MEASURE

TASK 1 (Objective 1): Give the child a pencil, a sheet of graph paper, and a copy of the following data.

Week	Number of Pieces of Paper Collected
1	25
2	20
3	15

Say, Make a graph of the information shown in this table of data. The child should construct a bar graph similar to that shown in Figure 6. Each bar should be drawn to the correct height.

TASK 2 (Objective 2): Ask the child, From the information you have in your graph, how much paper do you think is likely to be collected in the fourth week? The child should specify 10 pieces.

TASK 3 (Objective 3): Ask the child, How could you test your predictions? The child should describe a test he or she could carry out, such as collecting and counting the pieces of paper during the fourth week. The child should specify that the collecting would have to be done at the same time of the week and in the same place as the earlier collections.

Materials

Pencil, 1 for each child
Graph Paper, 1 spirit master (*Module 50*)

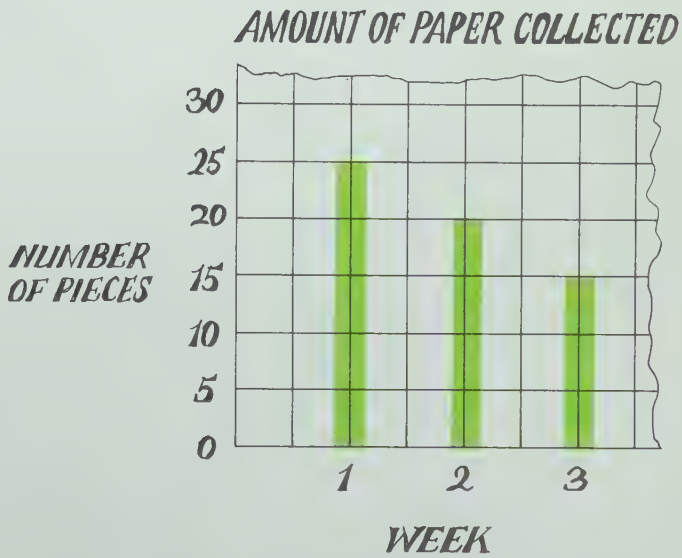

FIGURE 6

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50 Predicting/d

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MODULE
51

Using Space/Time Relationships/h

Rates of Change

OBJECTIVES

At the end of this module the child should be able to

1. *DEMONSTRATE* how to find the rate of change in a given amount of substance when the rate is measured in units of weight or distance or volume, and time.
2. *APPLY A RULE* to find the rate of change in position, or speed, of a moving object.
3. *DISTINGUISH* among objects according to their speeds, using terms such as "faster than" and "slower than."
4. *NAME* the whole number quotient for any division sentence, given a dividend less than 100 and a divisor less than 10.

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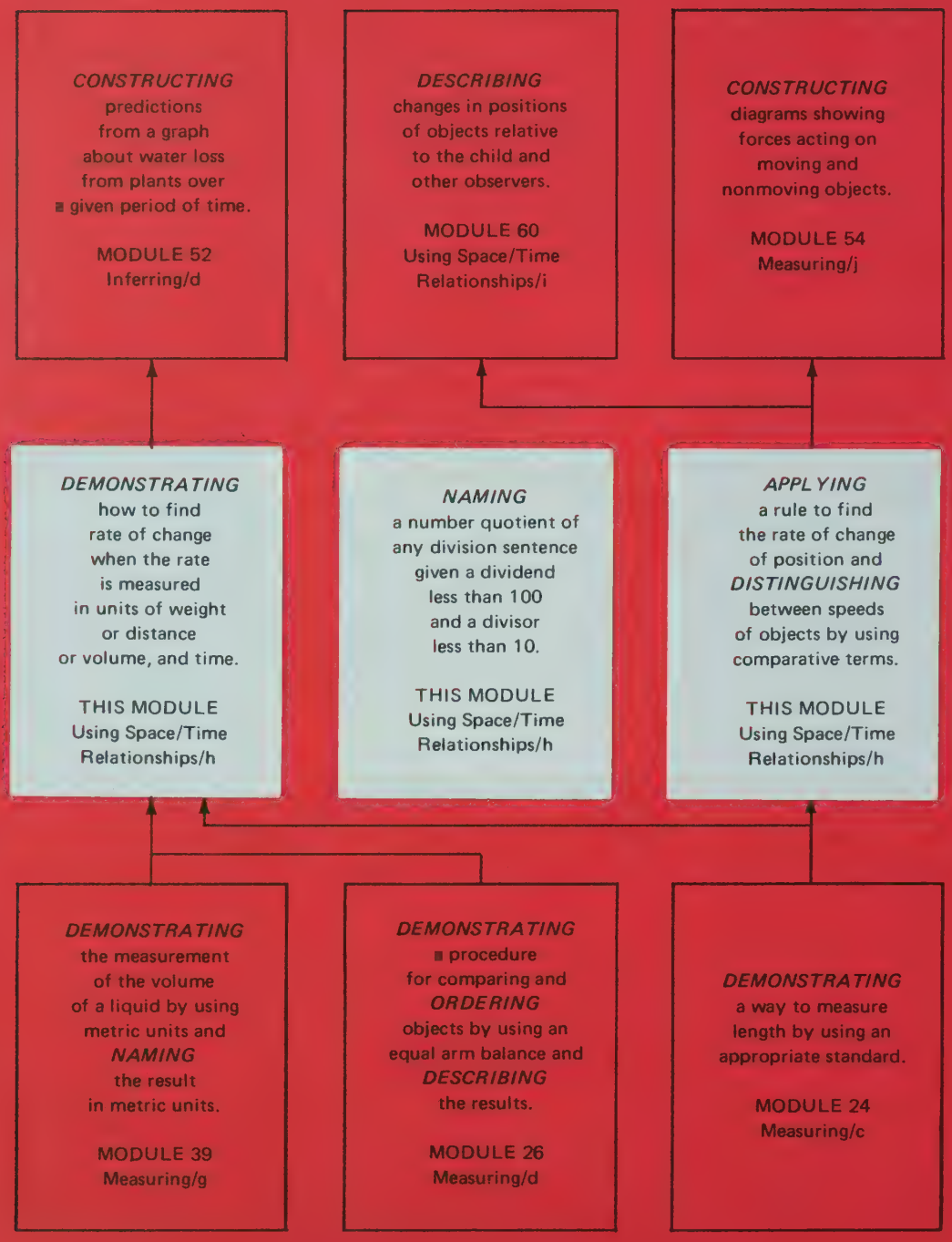
CONSTRUCTING predictions from a graph about water loss from plants over a given period of time.
MODULE 52 Inferring/d
DESCRIBING changes in positions of objects relative to the child and other observers.
MODULE 60 Using Space/Time Relationships/i
CONSTRUCTING diagrams showing forces acting on moving and nonmoving objects.
MODULE 54 Measuring/j
DEMONSTRATING how to find rate of change when the rate is measured in units of weight or distance or volume, and time.
THIS MODULE Using Space/Time Relationships/h
NAMING a number quotient of any division sentence given a dividend less than 100 and a divisor less than 10.
THIS MODULE Using Space/Time Relationships/h
APPLYING a rule to find the rate of change of position and *DISTINGUISHING* between speeds of objects by using comparative terms.
THIS MODULE Using Space/Time Relationships/h
DEMONSTRATING the measurement of the volume of a liquid by using metric units and *NAMING* the result in metric units.
MODULE 39 Measuring/g
DEMONSTRATING a procedure for comparing and *ORDERING* objects by using an equal arm balance and *DESCRIBING* the results.
MODULE 26 Measuring/d
DEMONSTRATING a way to measure length by using an appropriate standard.
MODULE 24 Measuring/c

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

The children have previously studied the concept of change and have described many different kinds of change, including changes in position, changes in color, and changes in size. In this module, the children learn to determine the rate at which change takes place, or the *rate of change*.

Rate of change can be expressed as the ratio of the number of units of any measured change to the number of units of time required for the change to occur.

In *Activities 1* and *2* of this module, the measured change is in the weight or volume of an object, specifically, the change in the amount of water as it evaporates. The children learn something about the process of evaporation and what variables affect it. They measure both the amount of change and the time in which the change occurs. They then express the rate of change in terms of the total measured change in weight or volume and the total measured time it took for the change to occur. Expressing the rate of change as so many units of weight or volume per one unit of time (1 second, 1 minute, and so on) requires some skill in division, and is not mandatory in the first two activities.

Activity 3 is an optional activity for those children who need practice in division. The activity is included because finding rates of change for a unit of time often requires division of a two-digit number by a one-digit number. The cover sheet and the answer book for the *Nine-t-Nine* game board on division might also be used for auto- or peer-instruction and practice.

In *Activity 4*, the children use toy cars to find average speeds, or rates of change of position expressed per unit of time. *Activities 5-7* are optional investigations among which the children should be allowed to choose. Each child should participate in at least one of the activities. In each situation, the children measure both distance and time to determine the distance traveled in a unit of time, or the speed of the given object. Briefly describe to the children the variety of activities possible so each child may decide which is of most interest to him or her. They may choose to work in groups, in pairs, or individually.

Vocabulary

evaporate	speed
evaporation	fast
condensation	faster
unit	fastest
rate	slow
rate of change	slower
position	slowest

INSTRUCTIONAL PROCEDURE

Introduction

Before class begins, prepare 2 graduated containers. Place masking tape along the side of a 250-ml container and, with the aid of a 50-ml graduated cylinder, calibrate the tape in units of 10 milliliters. Do the same with the second container. Fill each container with water up to the 50-ml mark. Put a cover on one container, leave the other open, and place both next to each other on a sunny windowsill.

At the beginning of class, call the children's attention to the containers. Ask the children whether the amount of water will remain the same in each container if the containers are left alone. Whatever the children conclude, leave the containers on the windowsill for several days. In humid weather, you might place the containers near a heating unit to speed up the evaporation. After a few days, ask for explanations for the difference in water levels.

Some of the children might suggest that the water in one container went into the air. If so, ask if it can be brought back out of the air. During discussion of this idea, you might take a glass from the refrigerator and comment on the water that has appeared on the sides of the glass. The children will probably be able to suggest other examples of condensation, such as dew, moisture on a car windshield, or frost on a windowpane.

Discuss with the children what happens to puddles when the sun shines on them, or what happens to wet clothes hanging in the sun. During this discussion, use the term *evaporation*, and ask the children to think of other

FIGURE 1

examples. The need for adding water to an aquarium would be a good illustration. A precise definition of evaporation is unnecessary. Do ask the children, however, if they know what happens to water that has evaporated.

Further profitable discussion may result from reference again to wet clothes drying in the sun. Why do some clothes dry more quickly than others? Will heating help to dry clothes? Other questions might center around how quickly boiling water will boil away ("boil dry"), and so on. Do not give many answers; stimulate the children to try to find answers for themselves.

Materials

Containers, 2, 250-ml, clear plastic, one with cover (*Module 49*)
Masking tape, 1 roll
Graduated cylinder, 1, 50-ml (*Module 49*)
Pencil, 1, for calibrating the tape
Drinking glass, 1, chilled in refrigerator

Activity 1

Call the children's attention again to the graduated containers of water on the windowsill. Have the children discuss again, briefly, what happened to the water in the open container. Then ask how they could measure the amount of water lost from a container. Suggest that they may also want to find out how "fast" water evaporates from a container.

Some of the children's suggestions for how to measure the amount of water lost might include the following methods.

1. Compare the weight of a container filled with water to a number of arbitrary units, such as washers or paper clips. This comparison could be made on the equal-arm balance at about the same time every day for several days. The difference in the numbers of units required to balance the container from one day to the next would be a measure of the weight of the water lost in a day's time.

2. Calibrate a container and fill it with water. Read the water level on the side of the container at about the same time each day. The difference in volume from one day to the next would be a measure of the liquid lost during the previous 24 hours.

3. Mark the water level on the side of a container, and add water with a dropper each day to maintain the original level. The number of drops needed each day is a measure of the water lost.

Of the above methods, the second and third probably are the easiest for the children to do. If air bubbles appear on the sides of the container, suggest that the children tip and rotate the container to release the bubbles before measuring the volume.

Divide the children into groups of three or four, and suggest that each group collect data about the amount of water lost through evaporation in a particular situation. Have the groups select their own situation to investigate. Some possibilities are as follows.

1. An uncovered shallow container of water.
2. An uncovered beaker about half-full of water.
3. A shallow container of water with aluminum foil or plastic wrap covering only half the top.
4. A container of water with an absorbent rag or paper immersed in it.
5. A container of water with salt or sugar disolved in it.

Another variable may be introduced by the location of the container of water. It might be indoors or out-of-doors, in sunlight or in a dark place, near or away from the radiator, and so on.

Tell the children they will be seeking answers to such questions as the following.

What is changing?
How much water is lost each day?
How many days does it take for all of the water to evaporate?

Give each child a copy of *How Much Water Evaporated?* Have each group collect data at the same time every day for 3 or more days, and have all the children record their group's data.

From their data, the children can calculate the amount of water lost each day, as well as the total amount lost over the three-day period. For instance, if a child had recorded the sample data shown in Figure 2, he or she could calculate that 15 milliliters were lost the first day, 13 milliliters the second day, and 14 milliliters the third day. Or, in three days, 50 minus 8, or 42 milliliters were lost. Have the children make such calculations using the data they recorded. Space for calculations is available on their data sheets.

Ask the children in each group, "What is the rate of water loss?" The children might phrase their answer as the total amount lost in the total time, such as, "42 milliliters were lost in three days." This is a satisfactory answer. You might, however, start the children thinking in more specific terms by asking how much water was lost in one day if the same amount of water evaporated each day. Use this as a way of telling the children that *rate of change* is usually expressed as a measured change per unit of time. Here, the

Container's original volume, in millimeters, or weight, in _____	Volume, in millimeters, or weight, in _____		
	DAY 1	DAY 2	DAY 3
50ml	35ml	22ml	8ml

FIGURE 2

unit of time is a day. In other situations it might be an hour, a minute, or a second. If some children know the answer, let them give it. The children should not be required to divide, however, until *Activity 3*.

Materials

Graduated containers, 2, from *Introduction*
Graduated cylinder, 1 (*Module 49*)
Equal-arm balances, 5, each consisting of a base, balance arm, two balance pans, two pan halters, and two sliding compensators (*Module 51*) (optional)
Paper clips, 1 box, or washers
Masking tape, 1 roll
Pencil, 1, or crayon, for calibrating the tape
Droppers, several (*Module 49*)
Containers, 10, 250-ml, clear plastic (*Module 49*)
Aluminum pie pans, 3 (*Module 51*), and other shallow containers
Beaker, 1, 1-liter (*Module 52*) and other deep containers
Various containers, several
Aluminum foil, 1 roll, or plastic wrap
Rag or paper towel
Salt (*Module 58*) or sugar
How Much Water Evaporated?, 1 spirit master, Figure 2 (*Module 51*)
Pencils, 1 for each child for recording data

Activity 2

Place on a table three or four pieces of wet cloth (see *Materials*) so that the children can see the display as they enter the room. Each piece should be labeled by type: nylon, orlon, gingham, and terry cloth. Say nothing about the pieces until the children mention them. As the day progresses, the pieces will begin to dry, some faster than others. As the children comment about this or ask questions, encourage them to talk about what is happening. Discussion should include the following ideas.

Do the pieces of cloth dry at different rates?
Which piece dries fastest? slowest?
How can we find out?
What is the rate of drying of each piece?

The children may suggest wetting the different pieces of cloth, hanging them up to dry, and touching them periodically. Continue discussion until the children have planned a reasonable procedure. Then give them the pieces of cloth and let them try their procedure as a group project. Put the final tabulation of their results on the chalkboard. It might look something like this:

Drying time, in minutes			
nylon	orlon	gingham	terry cloth
3	21	30	123

This investigation does not indicate why the pieces dried at different rates, but it does establish the difference in the rates of drying. Should the children continue to show interest, suggest that one or more groups of five or six conduct investigations that will yield data from which they can compute rates of drying.

Let the children plan their own method if their procedure will give reasonable results. Otherwise, suggest the following procedures, the first one requiring an equal-arm balance as the measuring device and the second requiring a spring scale. Explain that it will not be possible

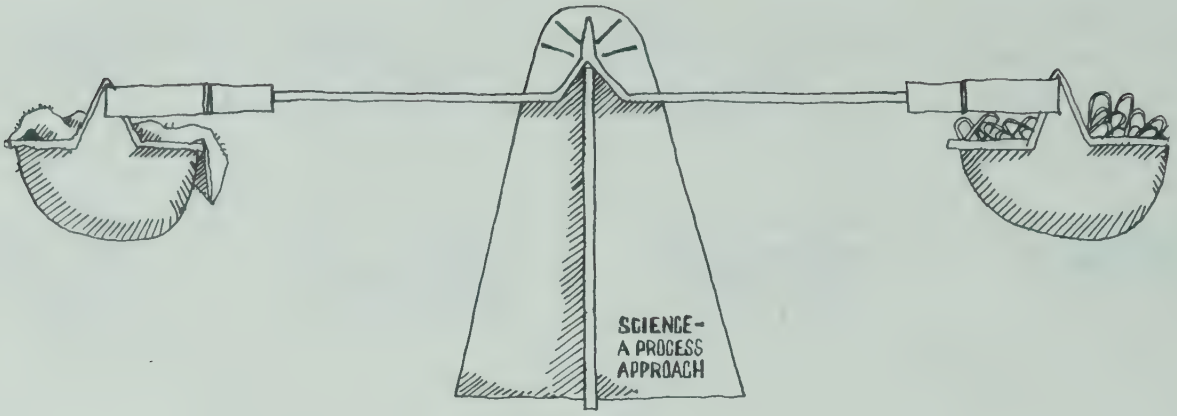

FIGURE 3

to devise a method in which the volume of water that has evaporated is measured directly.

1. Provide each group with an equal-arm balance, a box of small washers or paper clips, and four pieces of cloth. You may prefer to give a different kind of cloth to each group if several groups are participating. Also give each child a pencil and a sheet of paper.

Have the groups follow this procedure with each piece of cloth. Balance the dry cloth with washers or paper clips and record the weight. Then soak the cloth in water. When it stops dripping, fasten the cloth around the inside or top of one of the balance pans as in Figure 3. Weigh the wet cloth and record the weight. The difference in washers or paper clips between the wet and dry weighings represents the weight of the water in the wet cloth. Leaving the cloth in the pan, remove the washers or paper clips to balance the arms at 5-minute intervals, and record the number of washers or paper clips removed after each interval.

If the air is humid, the interval between weighing times may need to be longer. Some fabrics, such as the terry cloth, may also require longer intervals.

2. Provide each group with a spring scale, two paper clips, a box of small washers or paper clips, and four pieces of cloth. You may prefer to give a different kind of cloth to each group if several groups are participating. Also give each child a pencil and a sheet of paper.

The groups should use the following procedure with each piece of cloth. Soak a piece of cloth and wait until it stops dripping. Attach the wet piece of cloth to the pan with paperclips as shown in Figure 4. Read the centimeter scale on the tube to identify the position of the stretched spring. As the water in the cloth evaporates, the spring will contract to a lower-numbered position in the tube. After 5 minutes, place small washers or paper clips in the balance pan to extend the spring so that it returns to its original position. Add washers or paper clips at 5-minute intervals for at least 30 minutes. Keep a record of the number of washers or paper clips added at each interval.

While performing either method just described, the children should consider such questions as the following:

Is a change taking place?

Is the change taking place all at once?

How long will it take the cloth to dry?

After the groups have recorded their data, have them calculate the rate of drying and report their results to the other children. Remind the children that the number of washers or paper clips taken away or added is a measure of the weight of water lost. Be sure that the children report the time required for a measured change to take place, and stress that when they make such a report they are expressing a rate of change.

Ask the children to state the rate of water loss, that is the drying rate, for their group's type of cloth. They can express a rate as so many washers or paper clips in 30 minutes, or in whatever number of minutes was required.

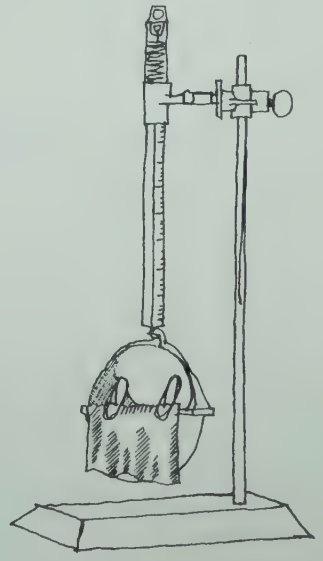

FIGURE 4

The children should recognize that different kinds of cloth take different lengths of time to dry. Have the children recall that water spilled on a dress or shirt sometimes dries quickly and at other times doesn't. Encourage the children to make inferences about these differences.

Materials

Cloth, 4 pieces: nylon, orlon, gingham and terry cloth (*Module 51*)
String, 1 ball, to hang the cloth to dry (*Module 51*)
Paper clips, 1 box for each group or washers
Equal-arm balances, 5, each consisting of a base, balance arm, two balance pans, two pan halters, and two sliding compensators (*Module 51*)
Spring scale, 1 for each group, each consisting of a support stand, burette clamp, pan, and spring apparatus with weakest spring (*Module 37*)
Writing paper, 1 sheet for each child
Pencils, 1 for each child
Timers, 6, or 1 wall clock

Activity 3 (Optional)

Activities 1 and *2* have indicated a need for some skill in division. For children who have some skill in division the *Nine-t-Nine* game may provide sufficient practice in division to meet their needs. For other children, you may want to design special practice sheets to be used with the game in order to provide more extensive experience.

The following ideas may be useful as you help the children develop their skill in division.

As the children use their recorded measurements to compute rates of change, they will need to answer such questions as the following:

How many sets or groups of 3 are there in 42?
How many sets or groups of 3 are there in 17?
$4 \times ? = 36$
$? \times 7 = 49$

You may also wish to have the children learn that $5 \times ? = 35$ and $35 \div 5 = ?$ ask the same questions. In other words, to find the rate of change in the example described in *Activity 1* (see Figure 2), the children could think as follows: How many sets or groups of 3 are there in 42? $3 \times ? = 42$, or $42 \div 3 = ?$

If you need to provide assistance in finding an answer to a question such as "How many 3's are there in 42?" encourage the children to follow a thought process such as the following:

ten 3's are 30
eleven 3's are 33
twelve 3's are 36
thirteen 3's are 39
fourteen 3's are 42

Or this process could be reversed, by repeatedly subtracting 3 as follows until a familiar relationship is encountered:

$$\begin{array}{cccc} 42 & 39 & 36 & 33 \\ \underline{-3} & \underline{-3} & \underline{-3} & \underline{-3} \\ 39 & 36 & 33 & 30 \end{array}$$

There are ten 3's in 30 and four more in 42, so there are fourteen 3's in 42.

Some children will understand better if they count by 3's. If necessary, they could do this by grouping 42 cubes or other objects into sets of 3 and then counting the sets.

No special issue need be made at this time of the remainder or how to represent the remainder. The answer to the question, "How many 3's are there in 17?" should merely be, "There are between five and six 3's in 17 because $5 \times 3 = 15$ and $6 \times 3 = 18$." In some circumstances, the child may wish to take one further step and say "There are almost six 3's in 17 (or more nearly six than five)." This answer can also be obtained by repeated subtraction. There is no objection to the introduction of any special remainder notation. Any such notation, however, will not be of much use in the children's science experiences.

Giving the children practice translating questions from words into symbols is recommended. The children will find it useful to know that the following are all different ways of asking the same question:

How many 3's are there in 39?
$3 \times ? = 39$
$? \times 3 = 39$
$39 \div 3 = ?$

Materials

Nine-t-Nine, 1 game
Writing paper, 1 sheet for each child
Pencils, 1 for each child
Cubes, 42, 1-cm (*Module 51*) or other objects

Activity 4

This activity introduces the children to the idea of rate of change in position, or speed. Change need not be expressed as a rate per *unit* of time. In *Activity 1*, for example, suppose that 42 milliliters of water were found to be lost in three days. It was not required that the children describe the loss per day. Now, however, you should require the children to express *speed* as a distance per unit of time, such as kilometers per hour or meters per minute. The children use the term "speed" in these activities, even though what they calculate is *average speed*. The distance need not be made at this time.

Send a small car across the room in a straight path. It might be a good idea to try the car beforehand. It should stop before hitting the far wall. Repeat the demonstration with a second car. Ask the children to tell in as many ways as they can how the cars move. How are the cars different? How are they alike? Do they move the same way?

When the cars move, a change takes place. Try to get the children to identify the change as a change in position. Ask for other examples of change in position. The children may suggest walking, running, riding in an airplane, throwing a ball, and other such movements.

Ask the children how they can decide which of two objects moves faster. Some children will probably say that it depends on "which goes farther." If so, push one of the cars across the floor and start walking after it. Let the car get ahead of you at first, but walk past it after it stops. Then ask which was faster, you or the car. The children will probably complain that it was not a fair race. Continue the questioning until someone suggests comparing the distances that you and the car moved in the same amount of time. The children should realize that they must consider both distance and time in deciding whether you or the car moved faster.

Have the children decide how to measure the speeds of the toy cars, and let them try their ideas. The use of the clock should be introduced here. Suggest the following procedure if the children do not initiate it themselves. Have the children make chalk marks 5 to 6 meters apart on the floor, to designate start and finish lines. Record the total distance in decimeters. Have two children race the cars. Caution them to move the cars carefully so they will travel in straight lines from start to finish. Have another child record the travel times on the board. After computing the speeds in decimeters per second, the children should express the idea that the slower car takes more time to travel the same distance.

Have the children mark two sets of start and finish lines on the floor, in different directions and at different distances, as in Figure 5. Have the slower car travel the shorter distance. When the cars are started together, the slower car should arrive at the finish line first.

Ask such questions as, "Which car moved faster?" and "Which car finished first?" Be sure the children understand that faster means at a greater speed, and that because the distances were different, the car that finished first is not necessarily the faster car. The trip of the slower car took less time, but the car traveled a shorter distance. You might have the children compare a plane flight from New York to Chicago and a car ride from home to school. The plane is faster than the car, but the car ride takes less time.

Materials

Toy cars, 2 (*Module 51*)
Chalk, 1 piece, for marking start and finish lines
Meterstick, 1 (*Module 48*)
Clock, 1, with second hand

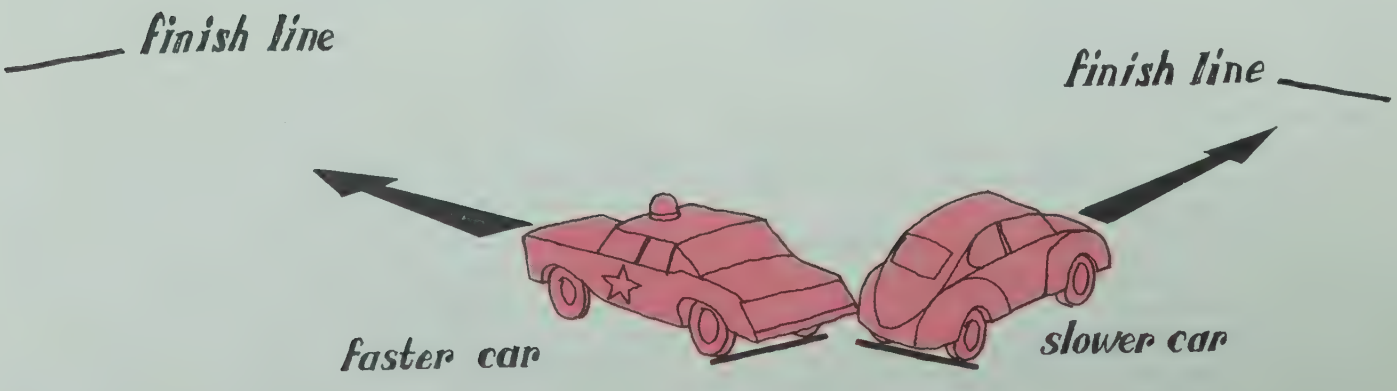

FIGURE 5

FIGURE 6

Activity 5 (Optional)

Have a child drop one unwrinkled sheet of paper and one sheet wadded into a ball from the same height (see Figure 6). Ask the children to describe what they see, to measure the rates at which the two pieces fall, and to record the rates. Also have the children record the height from which the two pieces fell. The child who drops the sheets of paper should stand on a table or chair to lengthen the falling time, making measurement easier and the different rates more noticeable.

Materials

Paper, several sheets
Meterstick, 1 (*Module 48*)
Wall clock, 1, or timer with second hand
Writing paper, 1 sheet for each child
Pencils, 1 for each child

Activity 6 (Optional)

During a physical activity period, have the children measure the speeds of five children hopping on one foot as fast as they can in a straight-line path. Ask the children to suggest the length of time that the hopping should be measured. One second is probably too short and one minute too long. Suggest that they measure how far the five children can hop in 6 seconds.

A possible technique is for one child to call, "One, two, three, go," for each hopper, while you stand farther down the course with the timer and mark the child's position at the end of 6 seconds. If you mark off a 30-meter string in meters or decimeters, and lay this along the course, each child can read off his own distance. When the procedure is agreed upon, begin the race.

After returning to the classroom, put the recorded data on the board or give each child a copy of the data. Ask everyone to find the speeds of the five hoppers by dividing the distances by 6. Be sure the children understand why they are dividing by 6. The result will be speed expressed as the number of units of distance per second. For example, if decimeters were used to measure the distances, the speeds will be in decimeters per second. On two additional days, record the distances hopped by the same five children. On these days, time periods of 8 and/or 10 seconds might be used. In any case, the resulting average speeds should be very close. If any child's speed varies considerably, have the children suggest why (John had a sore knee that day, etc.). With help from the hoppers, list the children in the order of their speeds.

FIGURE 7

Ask the children which child would arrive first if the five hoppers raced from one end of the playground to the other. Discuss how the average speed of each child could be used in predicting the winner of such a race. Ask the children for other examples when knowing such speeds would help someone predict what is going to happen.

Refer to the record of one child's speed and initiate a discussion such as the following: This shows how many decimeters Janet can hop in 6 seconds. How far can she hop in 12 seconds at the same speed? How far can she hop in 18 seconds at the same speed? Suppose she gets tired. How will this affect her speed?

Materials

Timer, 1, with second hand
Meterstick, 1 (*Module 48*)
String, 1 ball (*Module 51*)
Marking pen, 1, to mark string
Writing paper, 1-2 sheets for each child
Pencils, 1 for each child

Activity 7 (Optional)

Mark two start lines for courses running in different directions, but mark no finish lines. Start two toy cars from these lines at the same instant, but at different speeds.

Ask the children how they could find out if these cars are moving at different rates. The ensuing discussion should include the following kind of procedure. Start timing the cars when they begin their travel. After a given interval of time—1 second or 2 seconds, for example—mark how far each car has progressed. The car that has gone farther has traveled faster.

You might ask the following questions:

Suppose the first car went 3 meters in one second, and the second car went 6 meters in one second. (Point out these distances.) Which car traveled faster?

How would you describe the speed of each car? (3 meters per second, 6 meters per second.)

Which car would arrive first at a point 3 meters from the starting point? (The second car.)

Materials

Chalk, for marking start lines and distances cars travel
Toy cars, 2 (*Module 51*)
Wall clock, 1, or timer with second hand
Meterstick, 1 (*Module 48*)
Writing paper, 1 sheet for each child
Pencils, 1 for each child

Generalizing Experiences

Ask the children to describe situations in which data might be collected and a rate of change computed per unit of time. The situations must therefore involve a measurement of change in an object or event and a measurement of time required for the change to take place.

Such examples as the following might be mentioned.

Number of times you breathe in or out per minute.
Number of pulse beats per minute.
Number of kilograms you gain or lose per month.
Speed of your bicycle.
Speed of your father's car.

If the children express a desire to set up a situation they have described, to make the measurements, and to compute the rate, arrange for them to do this on an individual, paired, or small-group basis.

Ask some of the children to describe a changing object or event, and have other children tell what measurements would be needed, how they would obtain such measurements, and how they would compute the rate of change. Such accounts and exchanges could be carried on every day or two for several weeks.

One teacher hardened about 20 milliliters of olive oil by placing it in a refrigerator. When the olive oil was then brought into the warm room, the children measured the melting rate of the "solid." Encourage one group of children to try this, devising their own method for measuring the amount of melting. Have the children report their results to the others.

Materials

Olive oil, 20 ml, hardened in a refrigerator
(Note: Other substances that could be used in place of olive oil include ice cubes or bacon fat.)
Container, 1, 30-ml, to hold the olive oil or other substance (*Module 49*)
Writing paper, 1 sheet for each child
Pencils, 1 for each child
Wall clock, 1, or timer with second hand
Measuring devices, such as equal-arm balances (*Module 51*), graduated cylinders (*Module 49*), or metersticks (*Module 48*)

APPRAISAL

Pose such questions as the following to find out how well the children are able to use the idea of rate of change. Provide each child with pencil and paper for any calculations involved.

Which is faster, a man rowing a boat or a man walking? How can we find out if we cannot arrange for a race between them?

How can we find the speed of water in a river?

If a girl can walk 3 blocks in 6 minutes, how long will it take her to walk 1 block? (2 minutes)

There are 32 pieces of chalk in a box. If I use all the chalk in 8 days, what is the rate of change in the amount of chalk? How many pieces do I use per day? (32 pieces in 8 days or 4 pieces per day.)

I put 50 milliliters of water in a teakettle and boiled it. After 25 minutes of boiling, there was no water left. At what rate did the water leave the teakettle as steam? (50 milliliters in 25 minutes; 2 milliliters per minute.)

Materials

Writing paper, 1-2 sheets for each child
Pencils, 1 for each child

COMPETENCY MEASURE

Give the child a sheet of paper and a pencil for possible use in *Tasks 1, 2,* and *4.*

TASK 1 (Objective 1): Place before the child a funnel, a 50-milliliter graduated cylinder, a timer, and about 40 milliliters of salt, fine sand, or sugar. Say to the child, There are 40 milliliters of salt (sand or sugar) in this container. Pour the salt through the funnel into the cylinder. Show me how to find the rate of change in the amount of salt in the graduated cylinder. The child should pour the salt, measure the time required for all of the salt to run into the cylinder, and then say something like, "After 2 minutes there are 40 milliliters in the cylinder," or, "40 milliliters in 2 minutes." If the child says, "20 milliliters per minute," this is satisfactory, but not necessary for Objective 1.

TASK 2 (Objective 2): Place before the child a meterstick and a timer. Say to the child, I am going to roll a marble and I want you to find the speed of the marble. Tell me when you're ready. Beginning at the same start line used in *Task 3,* roll one of the marbles so that it does not reach the wall. The child should measure the distance the marble traveled and the time it took to go that distance, and divide the distance by the time, using whole numbers.

TASK 3 (Objective 3): Lay out a course on the floor, with the start line 5 or 6 meters from the wall. Simultaneously, shoot two marbles from the start line toward the wall so they travel at different speeds. Ask the child, Which marble is faster? The child should choose the correct marble.

TASK 4 (Objective 4): Ask the child, How many 5's are there in 75? The child should say, "15."

Materials

Writing paper, 1 sheet for each child
Pencil, 1 for each child
Funnel, 1, constructed by folding a piece of paper into a cone shape
Graduated cylinder, 1, 50-ml (*Module 49*)
Timer, 1, with second hand
Salt, 40 ml (*Module 58*) or sugar or fine sand
Container, 1, 120-ml, to hold the salt (*Module 58*)
Chalk, 1 piece, for marking start and finish lines
Marbles, 2 (*Module 48*)
Meterstick, 1 (*Module 48*)

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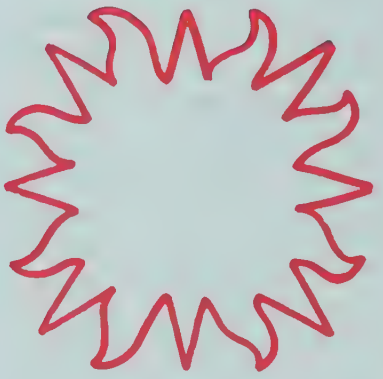
51 Using Space/Time Relationships/h

SCIENCE...



A PROCESS APPROACH II

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SCIENCE... A PROCESS APPROACH II

MODULE

52

Inferring/d

Plants Transpire

OBJECTIVES

At the end of this module the child should be able to

1. *CONSTRUCT* inferences about evaporation under various conditions.
2. *CONSTRUCT* inferences about condensation under various conditions.
3. *CONSTRUCT* inferences about water loss based on observation of plants.
4. *DESCRIBE* observations that can be used to test an inference.
5. *CONSTRUCT* a prediction from a line graph about water loss from plants.

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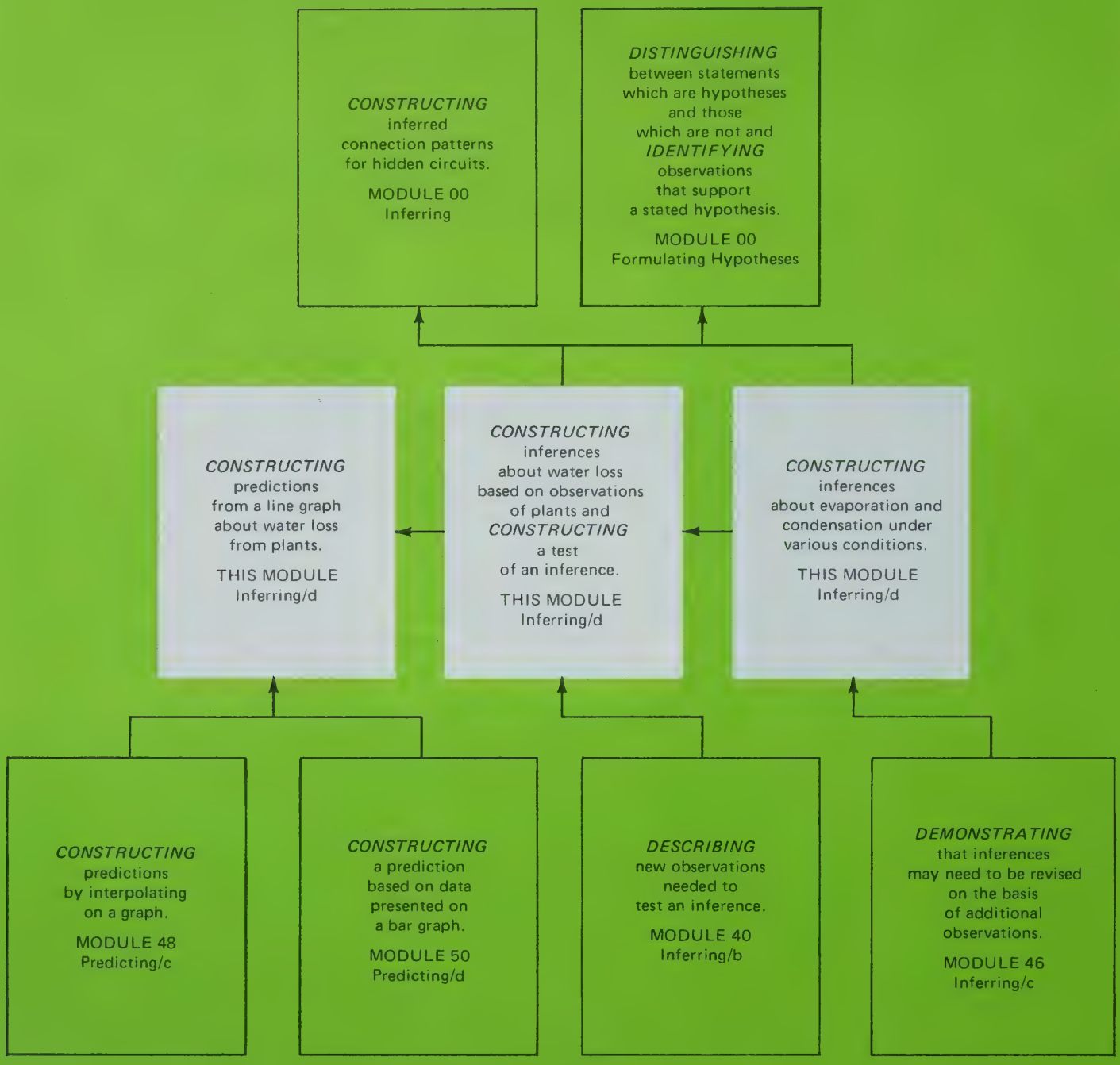
SEQUENCE


CONSTRUCTING inferred connection patterns for hidden circuits.
MODULE 00 Inferring
DISTINGUISHING between statements which are hypotheses and those which are not and *IDENTIFYING* observations that support a stated hypothesis.
MODULE 00 Formulating Hypotheses
CONSTRUCTING predictions from a line graph about water loss from plants.
THIS MODULE Inferring/d
CONSTRUCTING inferences about water loss based on observations of plants and *CONSTRUCTING* a test of an inference.
THIS MODULE Inferring/d
CONSTRUCTING inferences about evaporation and condensation under various conditions.
THIS MODULE Inferring/d
CONSTRUCTING predictions by interpolating on a graph.
MODULE 48 Predicting/c
CONSTRUCTING a prediction based on data presented on a bar graph.
MODULE 50 Predicting/d
DESCRIBING new observations needed to test an inference.
MODULE 40 Inferring/b
DEMONSTRATING that inferences may need to be revised on the basis of additional observations.
MODULE 46 Inferring/c

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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0-663-30408-3

RATIONALE

In this module, the children investigate some aspects of evaporation and condensation in physical systems. They also study water uptake, conduction, and transpiration in plants. They make observations about all these processes, construct inferences, and then design situations to test their inferences.

As the children learn that all living things are dependent upon water for survival, they may wonder why this important natural resource is not "used up." In this module they learn that plants take up water and, through transpiration, return part of it to the environment. Children also see that, through two physical changes, evaporation and condensation, water leaves the earth's surface and then returns. In *Soils, Observing i, Module 19*, the children learned that water trickles through the soil. If the water in the soil is not taken up by plants, it reaches a larger body of underground water. It then flows into streams, where it is used by plants and animals, or where some of it changes into water vapor. The water vapor returns again to the earth's surface as liquid water, through condensation and precipitation. This series of changes makes up the water cycle (see Figure 1).

In their future studies of living systems, the physical environment, and ecological relationships, the children will investigate in more depth the concepts relating to the water cycle. In this module, these concepts are merely introduced. Therefore, the subject matter in this module is highly appropriate for the development of skills in making and testing inferences.

Graphing techniques are also developed in this module. The techniques are an extension of those developed in earlier modules in which the children constructed and interpreted bar graphs. In *Activity 5*, the children work independently using the booklet, *Making a Line Graph.* Line graphs are used to record collected data and to make predictions in *Activity 6* and in *Activity 7.*

Activity 5 should begin early in the day so the children can make hourly readings and obtain results that will indicate the effect of sunlight on plant transpiration. It is a long activity and may extend over several days to include graphing and discussion of results.

Vocabulary

evaporation	transpiration
water vapor	water cycle
condensation	conducting tubes

Advance Preparation

Leafy branches are required in *Activity 5* (see *Materials*). If you conduct the investigation in the winter and cannot find suitable branches outdoors, obtain them from a local greenhouse.

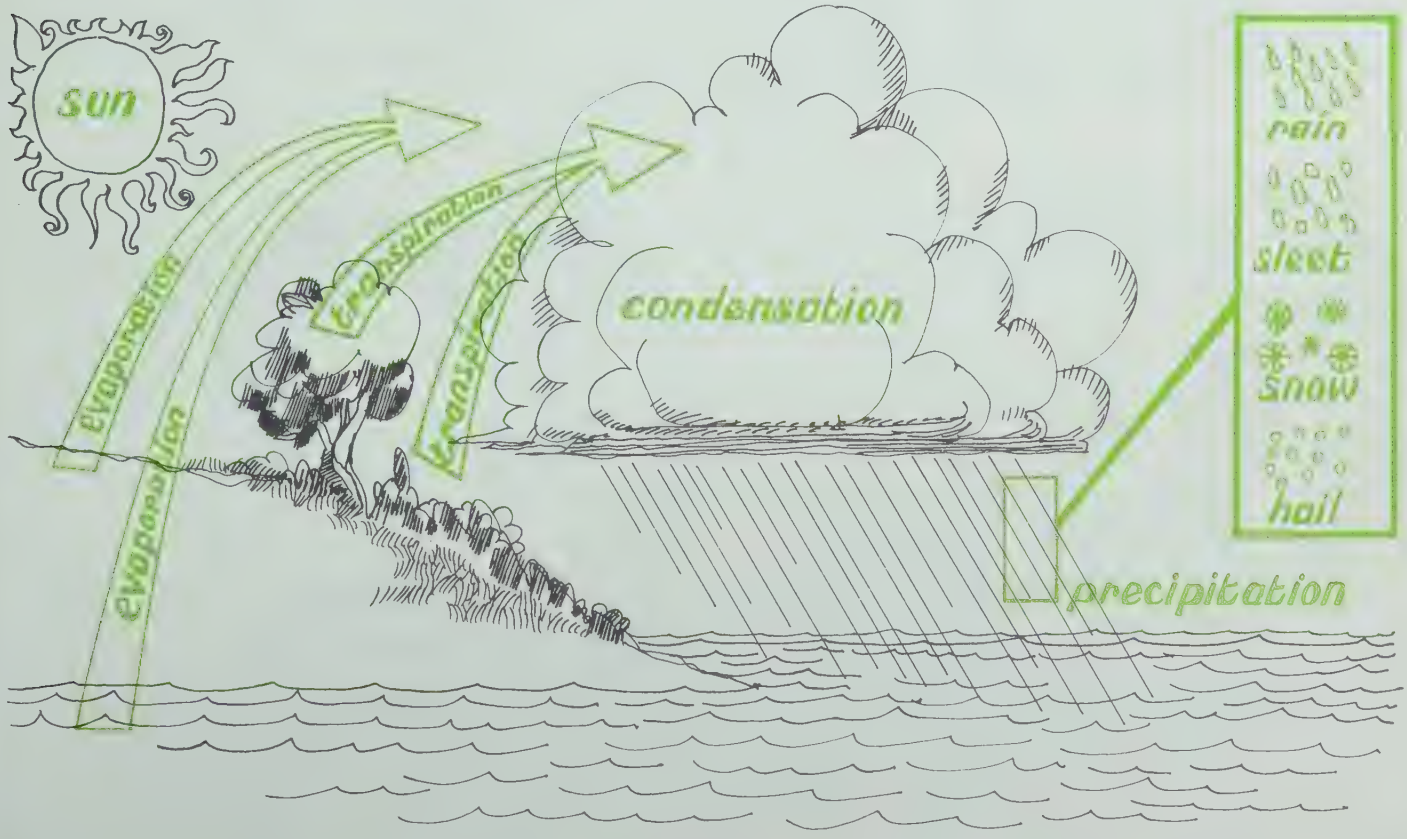

FIGURE 1

INSTRUCTIONAL PROCEDURE

Introduction

Ask the children to observe carefully what you do and what happens afterwards. Remind them to make observations, not inferences. Wash a section of the chalkboard with a wet sponge. As it begins to dry, ask the children for their observations, and list them on the chalkboard. Observations may include the following:

You went to the sink.
You wet a sponge with water.
You washed the board with the wet sponge.
After a while, the water on the board began to disappear.
The water first disappeared around the edges of the section you washed.

Now mark off two equal sections, separated from each other, on the chalkboard. Dampen and wring out two sponges. Pour an equal amount of water (about 50 milliliters) on each. Select two children and have each child wash a section of the chalkboard with one of the sponges. Both children should use the same procedure, up-and-down or cross-strokes applied with equal pressure, so that each section will have the same amount of water on it. Have one child use folded newspaper or a piece of cardboard to fan one of the sections. Allow the other section to dry without fanning it.

Have the children determine how long it takes each section of the board to dry completely. Again, list their observations on the board. Ask whether there was any difference in the drying time for the two sections. (The fanned section probably dried faster.)

Materials

Sponges, 2, each the same size (*Module 52*)
Graduated cylinder, 1, 50-ml (*Module 49*)
Folded newspaper or a piece of cardboard, to be used as a fan

Activity 1

Ask the children to make inferences to explain the observations they made in the *Introduction.* Some children will probably infer that the water went into the air, and that water goes into the air faster when the air is moving than when it is still. If no one suggests it, ask whether it is possible that the water disappeared by going into the board. Then ask what further observations might be made to find out whether the water went into the air or into the board.

Encourage the children to suggest tests, and let them carry out their tests, if feasible. One test might be to wet a section of the board and smooth a piece of plastic food wrap over a part of the wet section. If the section under the food wrap is still wet after the rest of the board has dried, the inference that the water went into the air is supported.

Materials

Sponge, 1 (*Module 52*)
Plastic wrap, 1 piece

Activity 2

Tell the children that when water disappears and goes into the air, it *evaporates.* Ask the children if they think anything other than moving air will speed up evaporation, and if anything other than plastic food wrap will slow down evaporation. Ask the children how they could test their ideas. Have them to carry out their suggestions.

You may wish to have the children try the following activity which provides opportunities to make inferences about evaporation and condensation.

Put about 500 milliliters of water in a beaker and put the beaker on a hot plate. Record the volume of water in the beaker, or mark the water level with a pencil on a masking tape label. Put 10 to 20 small bits of white paper in the beaker and turn on the hot plate.

Have the children observe the movement of the paper as the water warms up; have them note the time when the movement begins. As the water becomes hot and the bits of paper begin to move in the beaker, hold an aluminum pie pan or a piece of aluminum foil at an angle over the top of the beaker (see Figure 2). Ask several children to observe the pie pan and report their observations, including the time, to the others. Continue boiling the water until its level is obviously lower than it was at the start.

The children's observations should include the following statements.

After _____ (length of time), the paper began to move in the beaker.

After _____ (length of time), drops of liquid formed on the pie pan.

The water level in the beaker became lower.

Ask the children to make some inferences to explain their observations. Their inferences may include the following statements.

The temperature of the pie pan is lower than that of boiling water (because the teacher can hold the pie tin with bare hands.)

Water in the air changed back into large drops of water when the air hit the pie pan.

Heat caused the water to evaporate.

Tell the children that water in the air is called *water vapor,* and that water vapor *condenses,* or changes back to liquid water when it hits a cooler surface. Have the children discuss examples of evaporation and condensation that occur when food is cooked, or boiled. Similarly, you might ask what happens to windows in the winter? (Water vapor condenses when warm, moist air hits cold window panes.)

Materials

Beaker, 1, 1-liter, glass, heat resistant (*Module 52*)
Hot plate, 1
Masking tape, 1 small piece
Graduated cylinder, 1, 50-ml (*Module 49*)
Bits of paper, 10-20 pieces, white
Pie pan, 1, aluminum (*Module 51*), or piece of aluminum foil
Wall clock, 1
Pencils, 1 for each child
Writing paper, 1 sheet for each child

FIGURE 2

Activity 3

Review with the children how water went into the air after they washed the chalkboard. Ask what they think happens to the water that goes into the air. Why doesn't the earth dry up? (Because it rains.)

Divide the children into groups of five or six. Give each group pencils, paper, a thermometer, and a container about three-fourths full of water at room temperature. Ask the children to record the room temperature and the temperature of the water as their first observations, and to examine the outside of the container. Then add ice cubes to each container. Ask the children to continue making observations, including temperature changes within the container, changes on the outside of the container, and changes on the desk top where the container is placed. Moisture should form on the outside of the containers unless the humidity of the air is very low. Tell the children to be sure to record the temperature when any change takes place. Some of the children's observations might include the following.

The temperature at _____(time) is _____degrees; at _____(time) is _____degrees; and so on.
The ice cubes become smaller.
The ice cubes disappear at_____degrees.
Drops of moisture form on the outside of the container at_____degrees.
The desk becomes wet under the container at_____ degrees.

After the children have listed their observations, ask them to make an inference about where the water on the outside of the container came from. They may need some help with this. You might use such questions as the following to guide their thinking.

Was the water spilled? (No.)
Did the water come through the container? (No.)
Was the water originally at the same temperature as the air in the room? (Yes.)
When the ice was added to the water, what happened to the temperature of the liquid? (It fell.)
At that point, which was colder, the air in the room or the air just outside the container? (The air just outside the container.)

Now the children should be able to infer that when the warm air in the room came in contact with the cold container, the water vapor in the air condensed on the outside of the container.

Ask the children if they can explain how dew forms. If the children live in a cold climate, you might discuss frost as ice, or solid water, that forms on windows, grass, and bushes. Water vapor in the air turns to ice on a surface that is below freezing.

Materials

Containers, 6, 250-ml (*Module 49*)
Celsius thermometers, 6, $^{-}20^{\circ}$ to 110° (*Module 52*)
Writing paper, 1 sheet for each group
Pencils, 1 for each group
Ice cubes, 12-18
Wall clock, 1

Activity 4 (Optional)

Divide the children into five groups. Distribute to each group an ice cube and a 500-milliliter Erlenmeyer flask about half full of hot water. Have the children in each group place the ice cube on top of the Erlenmeyer flask and list their observations. (Fog forms and water droplets appear on the sides of the flask.) Ask the children to make inferences to explain their observations. (When the warm, moist air comes into contact with the cold ice cube, water vapor in the air condenses into tiny droplets, forming a fog or cloud.) You might mention that fog is a cloud that forms near the earth.

Materials

Ice cubes, 5
Erlenmeyer flasks, 5, 500-ml
Writing paper, 1 sheet for each group
Pencils, 1 for each group

Activity 5

Give each pair of children a copy of *Making a Line Graph*, a magic pen, two copies of *Line Graph Paper*, and two sheets of graph paper. Tell the children that the booklet explains a way to make a graph, a way that they will use in activities that follow. Proceed with *Activity 6* when all the children have completed the booklet.

Materials

Making a Line Graph, 15 booklets (*Module 52*)
Line Graph Paper, 1 spirit master (*Module 52*)
Magic pens, 16 (*Module 59*)
Graph Paper, 1 spirit master (*Module 52*)
(Note: Prepare one answer sheet so the children can check their work in *Making a Line Graph*.)
Pencils, 1 for each child
Metric rulers, 15 (*Module 47*)

Activity 6

Before class begins, cut one leafy branch for every two children (see *Materials*). Cut each shoot on the diagonal and immediately submerge the cut end in a large pail of water. Holding the branch under water, make a second diagonal cut through the branch at a point 2.5 to 5 centimeters from the cut end. The purpose of this second cut is to remove any air bubbles that may have formed in the water-conducting tubes after the first cut was made. Discard the small pieces of stem. *Keep the cut end of each branch underwater.*

Divide the children into teams of two. Give each team pencils, scissors, a sheet of graph paper, a metric ruler, a test tube, and a piece of modeling clay. Have one member of each team cut a strip of graph paper 2 centimeters wide and long enough to extend along the length of the test tube. Have that team member mark off the strip in millimeters.

While the first member of the team is marking off the strip, have the second member bring the test tube to where you have the supply of branches. Hold the test tube in the pail until it is full of water. Then, keeping the branch underwater, transfer it to the test tube. Remove the test tube, keeping the branch in place, and pour off some water so its level is about 1 centimeter below the top of the test tube.

Back at the work areas, have the children dry the test tube and add one or two drops of food coloring. (Note: During the investigation the food coloring makes it easier to see the water level. If you wish, the food coloring may be added to the water in the pail just prior to transferring the branches.) Have the children mold the modeling clay around the branch, filling the opening of the test tube to prevent loss of water by evaporation or spillage. Then have a child attach the graph paper strip with clear tape so that one of the centimeter lines is even with the water level. Have another child mark the water level on the graph paper, label that level *0*, and then label the remainder of the strip as shown in Figure 3.

Ask each team to identify its test tube before storing it in the rack.

Have the children keep an hourly record of the water level throughout the day. The record might look something like that shown below.

Time	Total distance the water level dropped, in millimeters	Difference in water level from previous level, in millimeters
9:30 A.M.	0.0	0.0
10:30 A.M.	1.0	1.0
11:30 A.M.	3.0	2.0
12:30 P.M.	5.0	2.0
1:30 P.M.	6.0	1.0
2:30 P.M.	8.0	2.0
3:30 P.M.	9.0	1.0

The rate at which the water level will fall depends in great part on the humidity in the room. If the humidity is high, it may be necessary to collect data over several days. Normally, however, one day's readings are sufficient.

After the observations are completed, discuss the data with the children. What total amount did the water level drop during the day? How much did it drop each hour? (Different amounts, probably.) If the data show it, point out that the amount the water level dropped each hour changed at different times during the day. This may not be

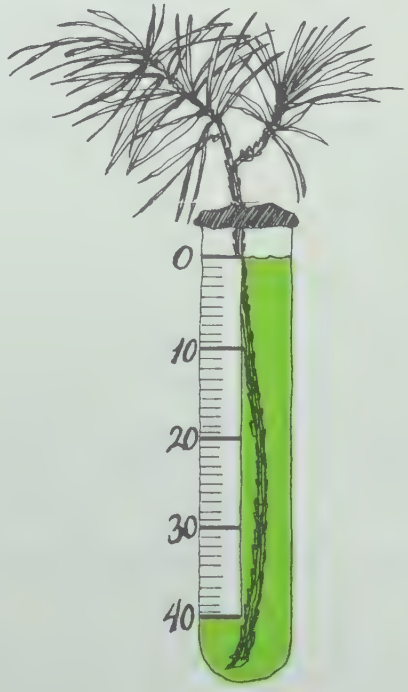

FIGURE 3

apparent, though, if the classroom temperature and lighting are relatively constant.

Ask the children to graph their results. Discuss with them what they should plot on the horizontal and vertical axes. Then make sure that they label the axes appropriately, indicating the units of measurement (hours, millimeters). Afterward, you might reproduce some representative graphs on the chalkboard.

Figure 4 shows two ways to graph the data. The first graph illustrates the total amount the water level dropped as time passed. The second shows how the drop in water level varied during each hour of the day. Although both graphs are based on the same data, they emphasize different aspects, and the children may have some difficulty seeing the relationship between them. If so, point out that the second graph shows the vertical distance between two successive points on the first graph.

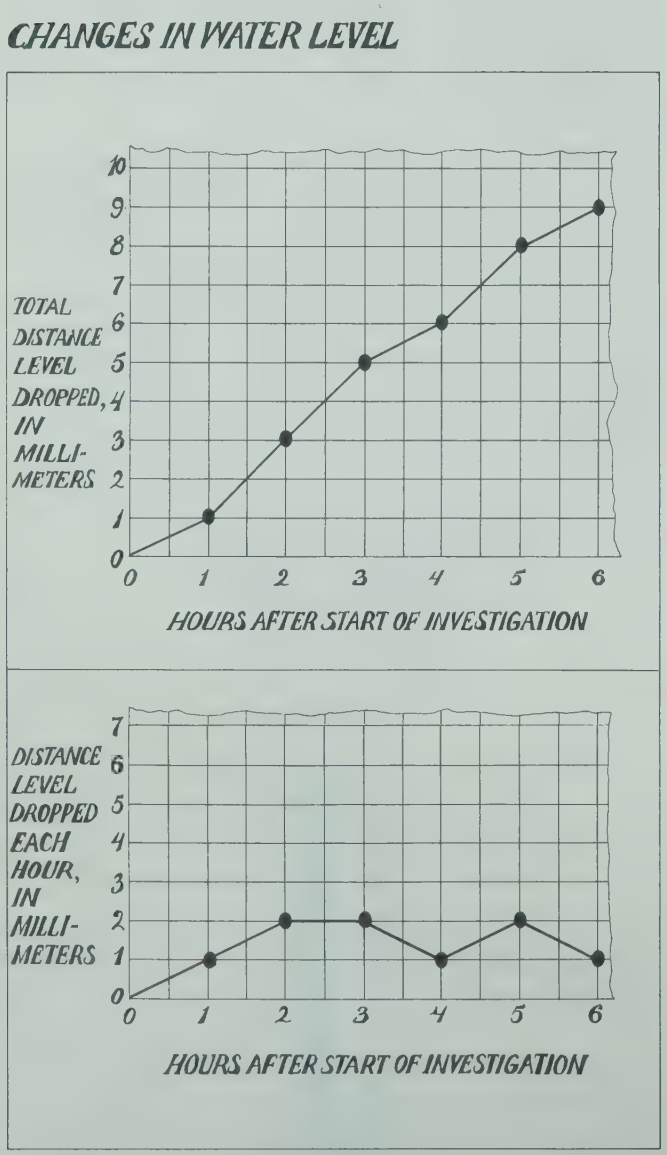

FIGURE 4

Ask the different teams to compare their results. The children should conclude that although their actual measurements varied, the trends are similar: Large plants used more water than small plants, and all plants used more water during the warm, bright part of the day. Ask the children whether their statements are inferences or observations. (Observations.)

You might point out that their measurements do not show the volume of water the plant used. To find this, some children could fill their test tubes to the *0* line with water and then pour the water into a graduated cylinder to measure the volume. At the end of the investigation, they could measure the water that is left. The difference is the volume of water that was used by the plant.

Ask volunteers to use their graphs to predict where the water level will be at 9:30 the following morning, that is 24 hours after the start of the investigation. If they predict that it will be below the bottom of the scale, suggest that before these children leave their setups for the day, they fill the test tubes so the water levels are at the top of the scales. The children should measure the water level at 9:30 the next morning. Their measurements probably will not agree with the predicted value, since plants do not transpire as much water at night as during the day. The failure of the prediction should stimulate both discussion and disagreement. This is good, provided the discussion remains logical and is not random guessing. Persistent questioning of a child who has an explanation should reveal whether the explanation is based on thought or guesswork.

Save the experimental setups for use in *Activity 7*.

Materials

Knife, 1, or pair of scissors
Leafy branches, 15, each about 6 mm in diameter, 35-40 cm in length
(Note: Branches of willow, pine, privet, sycamore, cottonwood, geranium, and tomato are all suitable.)
Large pail, dishpan, or sink, 1
Pencils, 1 for each child
Scissors, 15
Graph Paper, 1 spirit master (*Module 52*)
Metric rulers, 15 (*Module 47*)
Test tubes, 15 (*Module 52*)
Modeling clay, 1 package (*Module 52*)
Paper towels
Food coloring, 1 container, red (*Module 49*)
Clear tape, 1 roll
Test tube racks, 2 (*Module 52*)
Writing paper, 1 sheet for each group
Graduated cylinder, 1, 50-ml (optional) (*Module 49*)

Activity 7

After *Activity 6*, various questions may arise. The children should realize that they still do not know what happens to the water that the plant takes up or why the plant continues to need water. They may ask if water somehow gets out of the leaves and stems. They may want to know whether the leaves or the stems lose more water. And they may ask if both sides of the leaves lose water. Try to elicit these or related questions if the children do not ask them first. Let the children explore any ideas they have about finding answers to the questions.

Wherever possible, the children should use the equipment from *Activity 6* and the same technique to investigate the questions. You will need to cut more branches as you did in *Activity 6*. If the children do not suggest any procedures, briefly propose the following ones, but try to get the children to work out the details themselves.

Where does the water from the test tube go? Have the children add food coloring to the water in the tube. The children should observe the change in the coloring of the plant parts and infer that the water went into these parts. Point out the similarity of this investigation to the one in *Activity 6*.

Does water escape from the leaves and stems? Have the children wrap a plastic bag tightly around the plant and secure it with a rubber band. Have them examine this bag after a few hours. They should see droplets of water condensing on the inside surface of the bag. Ask where this water came from. Have the children draw inferences from their observations.

Which loses more water, the leaves or the stems? Have the children compare the amount of water the plant uses before and after the leaves are covered, on both sides, with a layer of petroleum jelly. The waterproof layer of jelly will prevent evaporation. Ask what inferences the children can make from their comparisons. You might ask the children where the water goes that leaves the plant. (Into the air.)

Do both sides of the leaves lose water? Two groups should cooperate on this test, each preparing similar setups with branches of about the same size and having the same number of leaves. One group should cover the upper surfaces of all the leaves with a thin film of petroleum jelly; the other group should cover the lower surfaces of the leaves. Have each group collect its data and compare the amount of water used in each setup. Ask the children what inferences they can make from their observations.

Encourage the children to keep whatever records they feel will help them communicate their procedures and results to the rest of the children. Have them use graphs wherever possible.

Tell group representatives or individuals to describe their procedures, results, and conclusions to the rest of the children. Point out any instances of missing information or information that was not recorded. Then discuss with the children whether their conclusions are observations or inferences.

At the end of the discussion, identify the process by which plants give off moisture as *transpiration*. In summary, ask what parts of the plants have been observed to transpire the most. (The underside of the leaves.) You might briefly describe the place of plants in the *water cycle* (see Figure 1), and then ask the following questions. Do animals, including man, use water? Do they give off water? How? (Perspiration, excretion.) Emphasize that both plants and animals are involved in the *water cycle*.

Materials

Items listed for *Activity 6*
Plastic bags, 15
Rubber bands, 15, to hold bags closed (*Module 54*)
Petroleum jelly, 1 container (*Module 52*)

Generalizing Experience

Encourage the children to suggest questions such as the following. How does water get into the plant? Where does it go when it gets into the plant? Discuss any activities that the children may suggest to answer these questions, and try them if possible. If the children do not suggest an activity such as the following, you might add it to the ones that they do suggest.

Put leafy celery stalks and a large pail of water on a table at the front of the room. Give each child a pencil and a sheet of paper. Tell the children they are going to see what happens when they put a cut celery stalk in colored water and let it stand for awhile. Ask them to observe everything that happens and to record their observations.

Give each child a plastic container about half full of water colored with red food-coloring. Have the children, in turn, bring their containers of red water to your supply of celery stalks and water. As each child watches, submerge the lower part of a stalk in the pan of water. Then, with a razor blade or sharp knife, make a diagonal cut completely through the stalk about 2.5 centimeters from the bottom. You must make the cut underwater to prevent air from getting into the conducting tubes in the stem. Also, the blade must be sharp enough to make a clean cut and to prevent the tubes from closing by being crushed or pushed together. Discard the small piece of stalk that you have cut off.

Now, ask the child to quickly transfer the stalk from the pail to the container of colored water. Tell the child to write his name on a masking-tape label for the container, put the container in a brightly lighted place in the room, and leave it there for several hours.

As soon as you notice a change in the color of the leaves, have the children retrieve their containers. Tell them to remove the stalk from the water and observe the stem and the leaves. Have them record as many observations as they can without any suggestions from you. Discuss their observations. If some of the children do not discover color in the leaves, suggest that they hold the leaves up to the light.

Cut across the stems in several places for the children and ask them to describe what they see. (See Figure 5.) Distribute the hand lenses among the children and suggest that they make further observations. They should see red dots. These are cross sections of the *conducting tubes*, although the children probably will not know this. Do not tell them what the dots are at this point.

Ask the children to break a piece of celery and to pull it apart. Again, they should describe what they see. This time the dyed strings or conducting tubes should be visible along their lengths. Ask the children to infer, from their observations, how the color reached the leaves. (It moved up through tubes.) Try to elicit this idea from the children without introducing it yourself. Now introduce the term *conducting tubes* and briefly discuss their function.

Materials

Celery stalks, 30, with leaves
Large pail, dishpan, or sink, 1
Pencils, 1 for each child
Writing paper, 1 sheet for each child
Containers, 30, 250-ml, plastic (*Module 49*)
Food coloring, 1 container, red (*Module 49*)
Razor blade, 1, or sharp knife
Masking tape, 1 roll, for labeling containers
Marking pen, 1, for labeling containers
Hand lenses, 15 (*Module 52*)

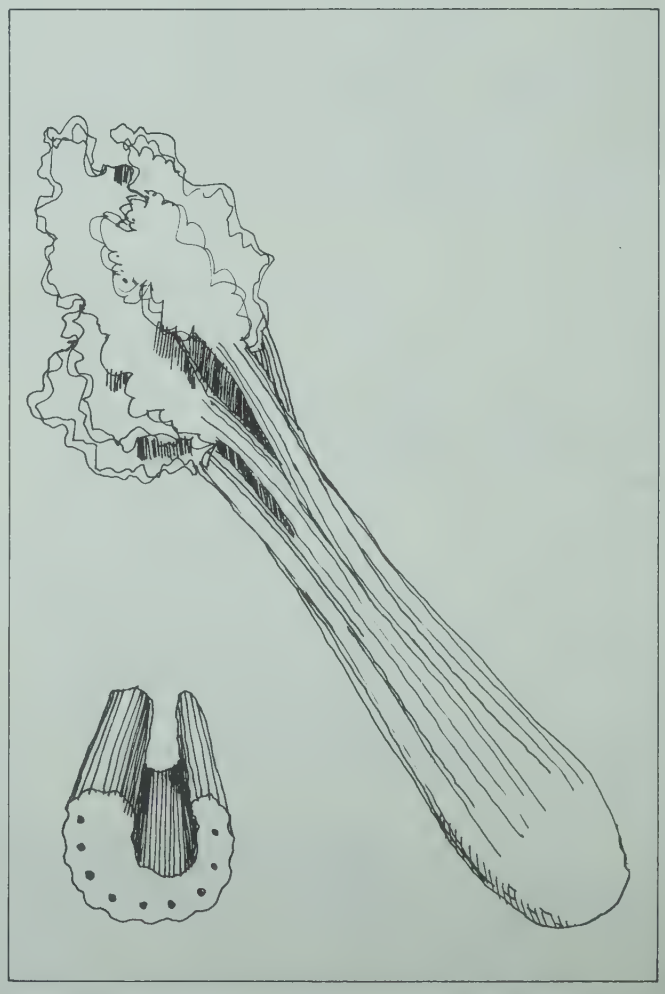

FIGURE 5

APPRAISAL

Ask the children why the inside surfaces of windows become moist on a very cold day, particularly in the bathroom when someone is taking a bath or shower. Discuss other times when windows may "fog," or when moisture forms.

Tell the children that you saw six carnations in a vase at the florist's shop and that three of the blooms were white and three were green. The florist told you that when he cut these carnations, all six were white. Ask the children to infer how the florist might have changed the color of the flowers.

Give each child a copy of *Willow Branch*, indicating the hourly rate of water uptake by a willow branch in a setup similar to that used by the children in *Activity 6*. Have the children suppose that a second study will be done after removing one-half of the plant's leaves. Ask the children to predict what the water level will be at each of the designated hours, and mark points on the graph to represent their predictions. Ask what observations they are using to make their predictions, and what inferences their predictions are based on.

Materials

Willow Branch, 1 spirit master (*Module 52*)
Pencils, 1 for each child

COMPETENCY MEASURE

TASK 1 (Objective 1): Say to the child, At 9:00 A.M., 300 milliliters of water were placed in each of two beakers. Neither breaker was covered. One was placed in the sun and the other was placed in the shade. At 3:00 P.M. the water levels in the two beakers were compared and it was found that the level was lower in the beaker that was placed in the sun. What inference can you make to explain the difference in water level? The child should say that the heat from the sun caused the greater evaporation of water loss.

TASK 2 (Objective 2): Say to the child, People who wear glasses and drive in air-conditioned cars on very warm, humid days often find that their glasses "fog up" when they get out of the cool car and into the warm air. What inference can you make to explain this? The child should say that water vapor from the air condenses when it hits the cold glasses.

Show the child the picture card illustrating Plants *A* and *B*, and say, This drawing shows two potted plants, labeled *A* and *B*, that are the same size. Plant *B* was completely enclosed in a large, airtight plastic bag. At 1:00 P.M., the two plants were placed one at each end of an equal-arm balance, which was then level. Plant *A* balanced Plant *B*. But by 3:00 P.M., the balance was no longer level.

TASK 3 (Objective 3): Ask, What inference can you make to explain why Plant *A* that was not in the plastic bag weighed less after two hours than Plant *B* inside the plastic bag? The child should say that water was lost from some part of Plant *A* (the soil, the leaves, or the stem), but that the plastic bag prevented loss of the water that evaporated from Plant *B*.

TASK 4 (Objective 4): Say, Tell me a way to test your inference. The child should suggest observations that can be used to test the inference.

Show the child the picture card illustrating a graph of hourly water loss, which shows data from an investigation like the one described in *Activity 6*.

TASK 5 (Objective 5): Say, Predict how far the water level measured in this investigation will have dropped after 6 hours. The child should say, "6 millimeters" or "about 6 millimeters."

Materials

Plants A and B, 1 picture card (*Module 52*)
Hourly Water Loss, 1 picture card (*Module 52*)

52 Inferring/d

SCIENCE...

A PROCESS APPROACH II

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MODULE
53

Predicting/e

The Suffocating Candle

OBJECTIVES

At the end of this module the child should be able to

1. *CONSTRUCT* predictions based on a series of observations that reveal a pattern.
2. *CONSTRUCT* a revision of a prediction on the basis of additional information.

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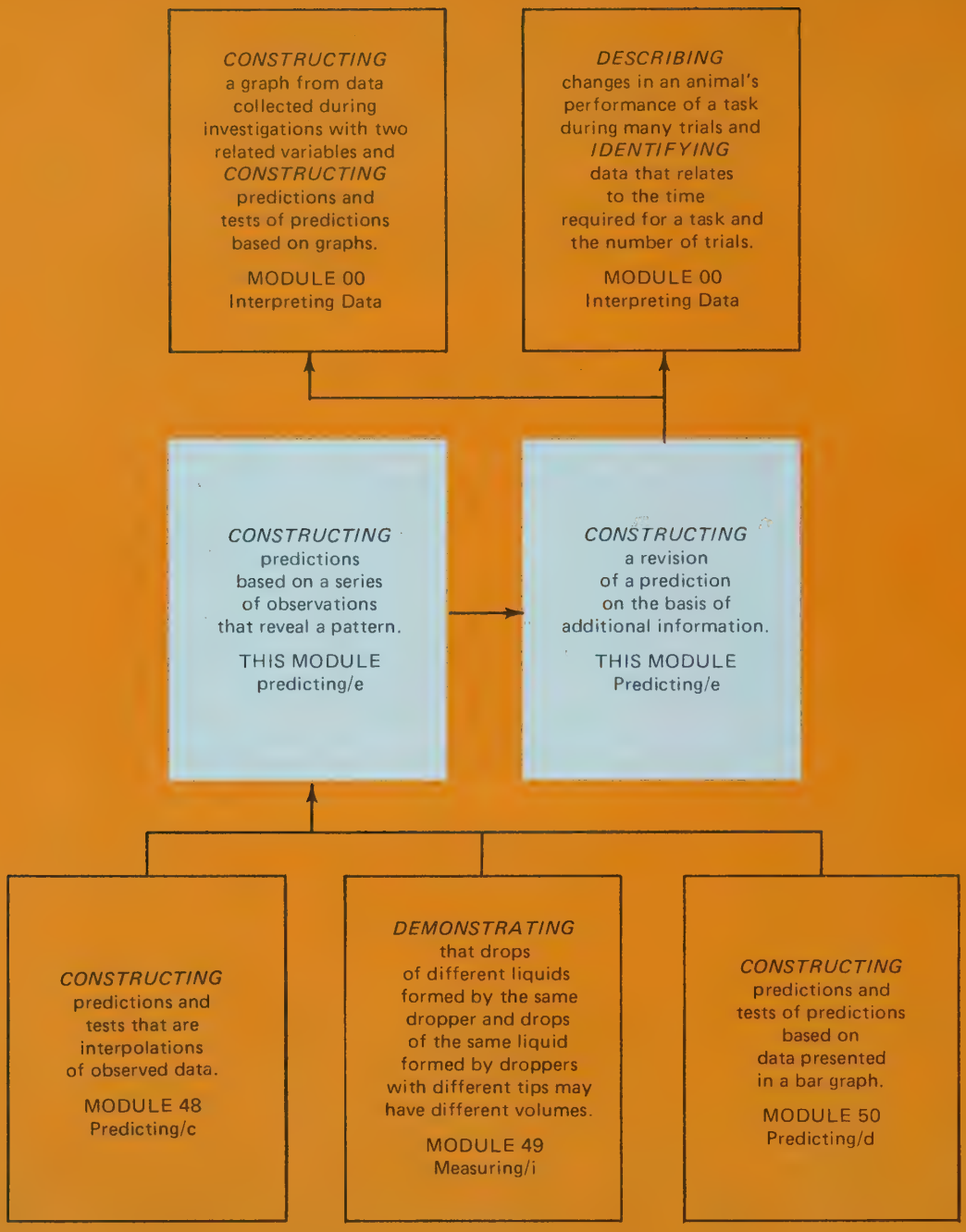
SEQUENCE


CONSTRUCTING a graph from data collected during investigations with two related variables and *CONSTRUCTING* predictions and tests of predictions based on graphs.
MODULE 00 Interpreting Data
DESCRIBING changes in an animal's performance of a task during many trials and *IDENTIFYING* data that relates to the time required for a task and the number of trials.
MODULE 00 Interpreting Data
CONSTRUCTING predictions based on a series of observations that reveal a pattern.
THIS MODULE predicting/e
CONSTRUCTING a revision of a prediction on the basis of additional information.
THIS MODULE Predicting/e
CONSTRUCTING predictions and tests that are interpolations of observed data.
MODULE 48 Predicting/c
DEMONSTRATING that drops of different liquids formed by the same dropper and drops of the same liquid formed by droppers with different tips may have different volumes.
MODULE 49 Measuring/i
CONSTRUCTING predictions and tests of predictions based on data presented in a bar graph.
MODULE 50 Predicting/d

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II**, is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

In this module the children investigate how long a candle burns when it is covered by inverted containers of various sizes. Using the data they have collected, the children then predict how long the candle will burn under a container of a size different from those they have already tested. Then they test their prediction. These procedures illustrate the sequence of operations that scientists frequently follow. A scientist looks for possible patterns in the data collected from observations and experiments. Then, reasoning from a suspected pattern, he or she predicts what the results will be if another experiment with somewhat different conditions is tried. The scientist carries out that other experiment. If the results of the new experiment turn out to be as predicted, the suspected pattern is supported. If not, the scientist looks for an alternative pattern in the full range of the data.

This module also introduces an important factor in scientific investigation. This factor is commonly called *experimental error; experimental variation* would be a better name because it does not arise so much from mistakes in carrying out a test as it does from small uncontrollable variables in the test system. When the children make several tests on the burning time of a candle under a particular container, they will probably find that even though they try to repeat conditions exactly, the burning time will vary by several seconds from one test to another. This is to be expected. A scientist takes the *mean* of the results of a series of similar tests and accepts the mean as most probably being closest to the "true" value. The children will calculate the mean values of their results and will plot these mean values on a line graph. And they will use their graphs to make predictions, both interpolations and extrapolations.

In *Activity 2* children learn to compute the mean of a set of numbers. You may wish to teach *Activity 2* first. There is, however, some advantage in the children's seeing a need for the mean in *Activity 1* before you introduce the computation.

Vocabulary

experimental error	interpolation
mean	extrapolation
average	

INSTRUCTIONAL PROCEDURE

Introduction

Place a candle in an aluminum pan and light it. If necessary, use some modeling clay to hold the candle upright. Put the pan with the lighted candle on a desk or table where all the children can see it.

Begin a discussion about fire and burning by asking questions such as the following:

What do you need to keep a fire going? (Wood, paper, or other fuel.)

Is fuel the only thing you need to get a fire started or to keep it burning?

Do some fires burn faster than others? What makes a fire burn faster?

How are fires put out?

Try to get the children to recognize that the rate of burning is usually related to the amount of wind or ventilation.

Ask what would happen if you put a container over the burning candle. (See Figure 1.) Do this, and let the children observe that the flame goes out. Ask the children to estimate the number of seconds the flame burned under the container. Record several of their estimates on the chalkboard. Now tell them that you will repeat the test so that they can measure the burning time by watching the second hand of a clock. Put such a clock on the table if there is none in the room. Light the candle again. Ventilate

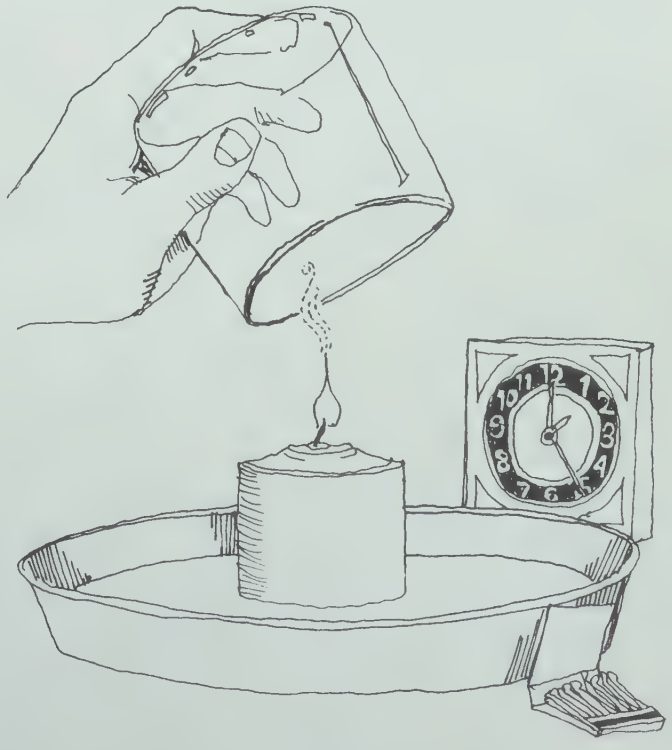

FIGURE 1

the container by wiping it out with a cloth or by turning it on its side and blowing into it, and then cover the candle again. When the flame goes out, ask again how long the candle burned after the flame was covered. Again record the amount of time reported. The amount will probably be different from the earlier estimates but not vary greatly. Suggest that you will repeat the activity once more so the children can test their measurements.

Repeat the trial and have all the children measure the time again. Ask if the time interval is the same as it was the last time. Probably it will not be. Ask which time interval is more accurate. Discuss this question and suggest reasons for the variations if the children do not. For example, ask questions like these: How do you know when to start the timing? How can you tell when the flame is really out? After some discussion the children should come to some agreement about when they will start the timing and when they will stop. They may decide to start when they see the container placed over the candle or when they hear the glass touch the pan; they may decide to stop the timing when they can no longer see the flame or when they see smoke rising from the wick. The children should use the agreed-upon points of reference in any similar tests.

Ask the children whether they think the burning time will be longer or shorter if the candle is covered with a container of a different size. After a short discussion, suggest that they investigate this question in the next activity.

Materials

Candle, 1, food-warming (*Module 53*)
Modeling clay, 1 small piece (*Module 52*)
Pie pan, 1, aluminum (*Module 53*)
Safety matches, 1 book
Container, 1, with wide mouth, glass
Clock, 1, with second hand

Activity 1

Divide the children into groups of five. Give each group a set of five glass containers of different sizes, an aluminum pan, a food-warming candle, a small piece of modeling clay, and matches. Be sure each child in each group has a specific task. Some suggestions are as follows:

1. One child could be the safety officer who holds the matches, lights the candle when necessary, puts the match out by dipping it in water, and watches to see that others do not get too close to the lighted candle. Of course, if regulations do not permit a child to light the candle, you will have to do this. Teacher aides or older children might be present to insure that proper safety precautions are taken.

2. Another child could be responsible for ventilating the container before each trial and putting the container over the lighted candle. Describe the procedures for ventilating the container. Stress that unless the air in the container is renewed between trials, the burning times may vary considerably. The container should be placed over the candle quickly, and it should not be held inverted above the flame for any length of time.

3. A third child could observe the candle and call "Start" and "Stop" at the agreed-upon points of reference.

4. A timer could watch the clock's second hand and read the time at the "Start" and "Stop" signals.

5. A recorder could write down the times that the timer called and calculate the interval. The recorder should record all times to the nearest whole number of seconds.

Instruct the groups to letter the containers in order with a china-marking pencil, from the smallest *(A)* to the largest *(E)*. Have the groups first make two or more measurements of burning time in Container *C* and record their observations in tabular form. (See Figure 2.)

In comparing the data from one group to another, the burning times might be quite different if Container *C* is of a different size in one set of containers than in another. This may generate some helpful discussion about the relationship between container volume and burning time. In any case, there is almost certain to be some variation in burning times.

No entry should be made under the heading "Predicted burning time" because no prediction has been made at this time.

If the children wonder why the results of successive trials with Container *C* are not identical, have them discuss the reasons for the variations. Several factors can influence the actual burning time and the observation of the burning time: the time lag between positioning the container over the candle and calling "Start," the time lag between realizing that the candle has gone out and calling "Stop," and variations in the length of the candlewick or the size of the pool of liquid wax at the base of the candle flame.

There is also the matter of renewing the air in the containers between trials. If you like, you might tell the children that variations in the results of similar tests are called *experimental error*.

Now ask the children to predict whether the burning time will be longer or shorter in Container *A*. Tell them to record a prediction *before* performing the test. After they have determined the burning time with Container *A* in a few successive trials, ask them to predict, but not record, the burning time with Container *B*. They will probably say that the burning time will be between the times they found for the two containers they have already tested. Ask them why they think this will be true. Someone will probably suggest that the larger the container, the longer the burning time, because the larger container has more air.

Before the children make any additional predictions or trials, ask them if they think they could make more accurate predictions if they knew the volumes or sizes of the containers. Ask them to suggest ways of measuring this volume. They may mention several. Continue the questioning, however, until someone suggests measuring the volume of water or sand that is needed to fill the containers. Then give each group a graduated cylinder. Have the groups make the volume measurements and record them in a column that they add to the table of data (see Figure 3).

Figure 3 shows actual results from a series of trials with containers of the volumes indicated. You may expect similar, but not necessarily identical results.

Now introduce a procedure involving the use of a graph to help the children make predictions. List the data shown in Figure 4 on the chalkboard. Tell the children that

Container	Predicted burning time, in seconds	Burning time, in seconds		
		Trial 1	Trial 2	Trial 3
C				
A				
B				

FIGURE 2

Container	Predicted burning time, in seconds	Burning time, in seconds				Container volume, in milliliters
		Trial 1	Trial 2	Trial 3	Mean	
C	——	32	28	35		500
A	(shorter, maybe 8)	8	9	10		125
B	18, 16, 14, or 20					250
D						1,000
E						2,000

FIGURE 3

another group of pupils collected these data. Then, using an overhead projector and a transparency of *Graph Paper,* have the children help you plot all of the points on the graph and draw lines connecting the highest and lowest readings for the two container sizes, as in Figure 5. Point out that the children could use the shaded area between these lines for making predictions by interpolation. For example, they might say that a candle under a 600-milliliter container would burn between 12 and 15 seconds.

Using the volume measurements and the graphing technique, the children can now predict with more confidence. Give each group a sheet of graph paper on which to plot the information for Containers *C* and *A,* and have the groups predict the burning time for Container *B.* Have them test their predictions and record the measured burning times found for Container *B.* Containers *D* and *E* will be used in *Activity 3.*

Materials

Containers, 1 set for each group, each set consisting of
five glass containers of different sizes
(Note: Five containers of the following sizes are suggested—small juice glass of about 125 ml, large juice glass of about 250 ml, large drinking glass of about 500 ml, wide-mouthed bottle of about 1 liter, wide-mouthed bottle of about 2 liters.)
Pie pans, 6, aluminum (*Module 53*)
Candles, 6, food-warming (*Module 53*)
Modeling clay (*Module 52*)
Safety matches, 6 books
China-marking pencils, 6
Clock, 1, with second hand
Sand
Graduated cylinders, 6, 50-cm (*Module 49*)
Transparency, 1, duplication of *Graph Paper* (*Module 48*)
Overhead projector, 1
Graph Paper, 1 spirit master (*Module 53*)
Pencils, 1 for each group
Writing paper, 1 sheet for each group

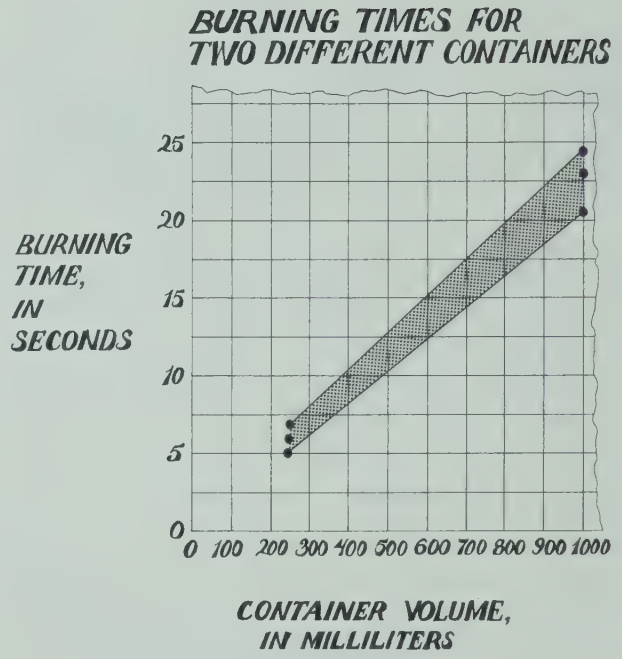

FIGURE 5

Container volume, in milliliters	Burning time, in seconds		
	Trial 1	Trial 2	Trial 3
250	6	5	7
1,000	24	23	21

FIGURE 4

Activity 2

If your children know how to find the mean, or average, of a set of numbers, this activity may be omitted.

Show the children 5 strips of heavy paper that vary in length from 6 to 8 decimeters. Ask the children about how long the strips are in decimeters. They will probably say that they are of different lengths. Ask them what one number might be a good estimate for all the lengths. It is not necessary that all the children agree. Tell them that some people call this number the *mean length* or the *average length.* You may wish to use the word *average* here instead of *mean.* There are several kinds of averages; the mean is only one kind. The children will not need to learn this distinction at this time.

After the children have made an estimate, select five teams of two children each to measure the strips with a meterstick. Suppose they find that the lengths in decimeters are 6, 7, 7, 6, and 8. The children would probably agree that the strips are about 7 decimeters long. Ask the children what the total length of five strips, each 7 decimeters long, would be. (5 x 7 = 35 decimeters.) Then ask them the total length of the five strips they measured. The children may add the five lengths, or they may lay the strips end to end and measure the total length. In the case considered here, the total length of the strips would be 34 decimeters. When comparing the two totals, 34 and 35, the children probably would be willing to agree that 7 decimeters reasonably represents a mean length for the 5 strips. Now ask, "34 ÷ 5 = ?" Elicit "34 ÷ 5 is between 6 and 7." Therefore the mean length of the strips is between 6 and 7 decimeters; and to the nearest whole number, it is 7 decimeters.

If appropriate, explain to the children that first we find the mean or average of whatever numbers we are studying, and then we use the unit of measurement in stating the result. In the example above, the mean of the numbers is between 6 and 7; the mean length is between 6 and 7 decimeters.

Now ask the children to find other means in easy situations — for example, the mean of 3, 4, and 5. At first you may have to suggest that the numbers are added and the sum is then divided by the number of numbers: 3.

```
  3
  4
+ 5
 12
```

$12 \div 3 = 4$
The mean is 4.

Or, what is the mean of 5, 7, 8, and 10?

```
  5
  7
  8
+10
 30
```

$30 \div 4 = 7$, remainder 2
The mean is between 7 and 8.

Ask the children to do examples like these at their desks. Ask them to show you their work.

During the year, many kinds of counting and measuring activities provide opportunities for the children to practice finding means of sets of numbers.

Materials

Heavy paper strips, 5, lengths from 6 to 8 decimeters
Writing paper, 1 sheet for each child
Pencils, 1 for each child
Meterstick, 1 (*Module 48*)

Activity 3

Have the children compute the mean burning time for each container from the trials recorded during *Activity 1* and have them record the means in an additional column (see Figure 3).

Now ask the children to predict the burning time of the candle in Container *D*. If that container has a volume of about 1 liter (approximately twice that of Container *C*), the children will probably predict a burning time twice that in Container *C*. Other predictions are also possible. Do not permit the children to test their predictions at this time, but ask them to make a prediction of the burning time in a nonexistent container that has a volume of, say, 600 milliliters. They will probably suggest using the graph they made earlier. Allow them to discuss their predictions and then ask them if they can think of a way to present the data they now have recorded in their tables so they can make their predictions more precise.

If no one suggests graphing, you should. Give each group a sheet of graph paper. Then help the children decide answers to questions like those that follow. What variables should be graphed? (Volume, burning time.) Remind the children that this time they could plot mean burning time. What variable has been measured? (Burning time.) What condition has been changed? (Volume.) Which axis, horizontal or vertical, should be used for each variable? Although either volume or burning time could be plotted on the horizontal axis, the variable that is voluntarily changed—here, volume—is customarily plotted on the horizontal axis; the variable that is measured—here, burning time—is then plotted on the vertical axis.

After each group has graphed its own data, make a graph of the data from one group on a transparency for the overhead projector so all the children can discuss the graph. Figure 6 shows what this graph might be like.

Ask the children how they would use a similar graph to predict the mean burning time of a candle under a 400-milliliter container. Someone will probably suggest marking a line from the point for a volume of 250 milliliters to the point for a volume of 500 milliliters and reading the mean burning time where the marked line

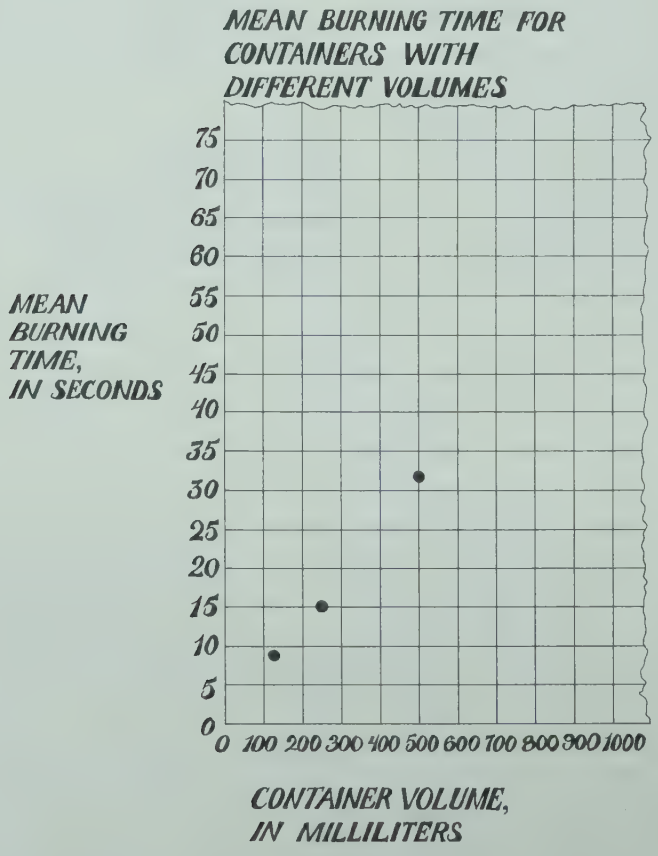

FIGURE 6

crosses the vertical line for 400 milliliters. Lay a ruler across the three points on the transparency and ask whether the point for the 125-milliliter volume should be considered. Eventually, the children will probably all agree that the three points fall close to a straight line, and that they could make their predictions from a straight line drawn through these points. You may wish to draw a straight line through the points.

Have each group draw lines to connect the points plotted on their graph and write their predictions on the burning time for a 400-milliliter container on a separate sheet of paper. Ask the children if they feel quite sure that this prediction is very close to the burning time they would observe if they used a 400-milliliter container. (Probably yes.) Is this a fairly reliable prediction? (Yes.)

Now ask the children to make predictions for a 600-milliliter container, again, and also for Container *E*. Ask questions about how they will do this. Finally someone should suggest extending the straight line through the points on the graph and across the vertical line for both the 600-milliliter volume and for the volume of Container *E*. Extend the line on the transparency, and have each group do the same on their graph. If the lines run off the paper, help the children tape another piece of graph paper to the first so that they can draw the extension. Again, have them record their predictions on their tables of data or on a separate sheet of paper. Ask the children how reliable they think these predictions are. Do they feel more confident about the predictions for the 600-milliliter volume container than for the one with the largest volume? Why?

Have the groups measure the burning time for Container *E* to test their predictions, and tell them to enter their measurements on their graph. Ask if the first straight line is justified or whether it needs to be modified. Ask the children what predictions they would now make for the burning time under Container *D*. Ask them to measure that burning time and test their predictions.

Now review the meaning of the terms *extrapolation* and *interpolation*. Interpolation involves predicting values between those actually observed, whereas extrapolation involves predicting values beyond those observed. Ask the children questions, such as the following:

In terms of your observations, does interpolation or extrapolation give the more reliable basis for prediction?

How does the reliability of an extrapolated prediction change as you get farther and farther from the observed points? (The more extreme the extrapolation, the less reliable it becomes.)

What are the reasons for your answers?

Some individuals or groups may want to try to use containers of intermediate sizes to test some of their predictions or to plot other points on the graph.

Materials

Tables of data, from *Activity 1*
Graph Paper, 1 spirit master (*Module 53*)
Metric rulers, 30 (*Module 47*)
Transparency, 1, duplication of *Graph Paper* (*Module 48*)
Overhead projector, 1
Containers, 1 set for each group, each set consisting of five containers of different sizes, glass (see *Materials, Activity 1*)
Pie pans, 6, aluminum (*Module 53*)
Candles, 6, food-warming (*Module 53*)
Modeling clay (*Module 52*)
Safety matches, 6 books
Clock, 1, with second hand
Pencils, 1 for each child

Generalizing Experiences

Suggest that the groups study the variation in burning time in other ways; one or more of the following ways might be used.

The container might be systematically elevated. For example, plastic cubes might be stacked symmetrically under a container to raise the container to various heights.

The candle might be moved systematically from a central location within the mouth of the container toward a final position against the rim. Positions of the candle can be more varied if a wide-mouthed container, such as a large peanut butter jar, is used.

The height of the candle in the container might be varied by setting the candle on one or more cubes.

Various types and sizes of candles might be used.

Groups might study the variation in burning time that results from intentionally not renewing the air in each container after each trial.

Materials

Containers, 1 set for each group, each set consisting of five containers of different sizes, glass (see *Materials, Activity 1*)
Pie pans, 6, aluminum (*Module 53*)
Candles, 6, food-warming (*Module 53*)
Candles, 6, birthday (*Module 53*)
Safety matches, 6 books
Cubes, 24, 1-cm (*Module 51*)
Clock, 1, with second hand
Pencils, 1 for each group
Writing paper, 1 sheet for each group

APPRAISAL

Give each group of children a container and ask the groups to predict the burning time of a candle under this container. Ask how they would do this. They should suggest measuring the volume of the container. Ask them to make the measurement and then predict the burning time. They should predict from their graphs. If the children do not, ask them specifically to use their graphs to make another prediction. Then ask them to test their predictions by determining the burning time. Check to see that they make the measurement two or more times, rather than just once, and that they report a mean burning time. Then ask them to compare their observed mean burning times with their predictions. Also ask whether their predictions were interpolations or extrapolations and how they would interpret the results.

Materials

Containers, 6, tall and narrow, glass
Candles, 6, birthday (*Module 53*)
Pie pans, 6, aluminum (*Module 53*)
Modeling clay (*Module 52*)
Safety matches, 6 books
Clock, 1, with second hand
Pencils, 1 for each group
Writing paper, 1 sheet for each group

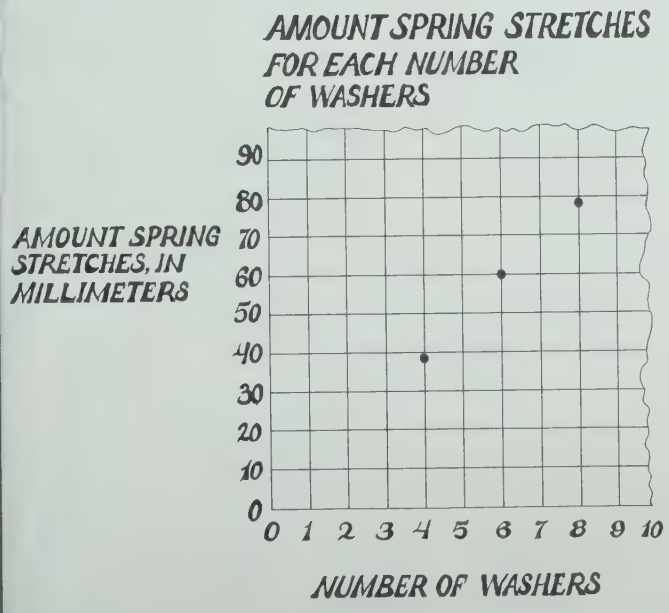

FIGURE 7

COMPETENCY MEASURE

TASK 1 (Objective 1): Give the child a copy of the graph shown in Figure 7. Tell the child that the graph shows that four washers stretched a spring 38 millimeters (indicate the point on the graph), six washers stretched the spring 60 millimeters, and eight washers stretched it 78 millimeters. Give the child a ruler and a pencil and say, Make an *X* on the graph to show how far you predict three washers will stretch the spring. The child should make an *X* on the vertical line above 3 somewhere above the 38 millimeters line.

TASK 2 (Objective 2): Now say, A test was conducted in which two washers were suspended from the end of the spring. The spring was found to have stretched 20 millimeters. Put another dot on the graph to show this added information. Ask, Would you like to change your prediction of the amount the spring stretched when three washers were suspended from it? If the child's prediction was about 30 millimeters, he or she should indicate no desire to change the position of the *X*. If the prediction was not 30 millimeters, the child should indicate a desire to change the prediction and make an *X* to represent a stretch of approximately 30 millimeters.

Materials

Graph Paper, 1 spirit master (*Module 53*)
(Note: The graph shown in Figure 7 will have to be copied for each child.)
Metric rulers, 3 (*Module 47*)
Pencils, 1 for each child

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53 Predicting/e

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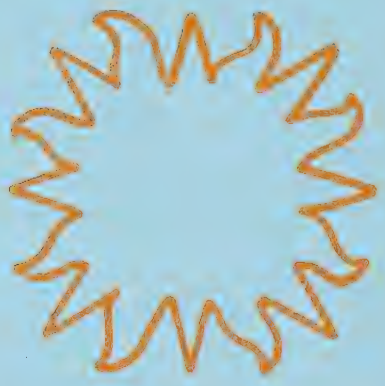

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SCIENCE...
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APPROACH II

MODULE
54

Measuring/j

Static and Moving Objects

OBJECTIVES

At the end of this module the child should be able to

1. *DESCRIBE* forces acting on nonmoving objects.
2. *DESCRIBE* forces acting on moving objects.
3. *CONSTRUCT* diagrams showing the forces acting on moving and nonmoving objects.

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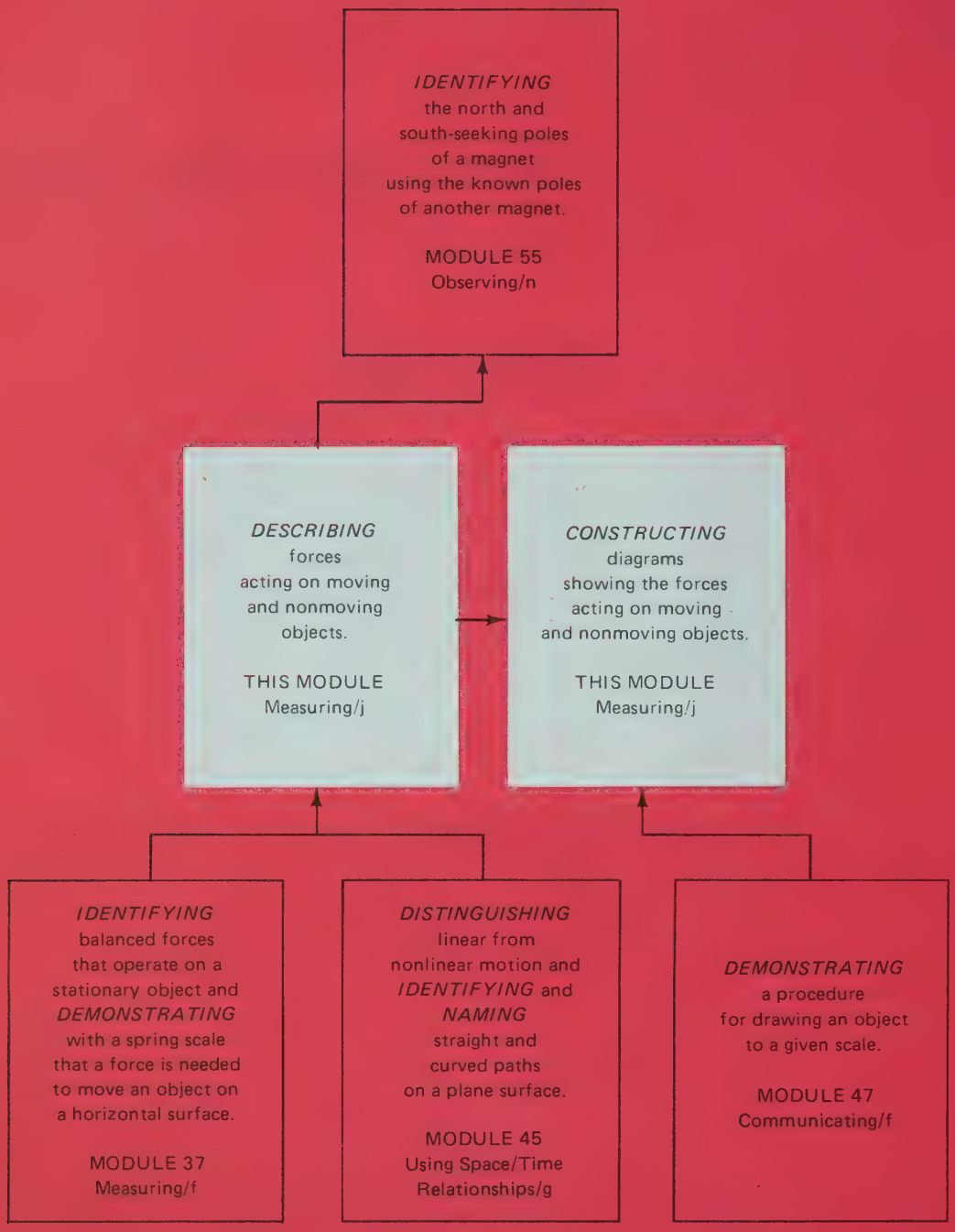
SEQUENCE


IDENTIFYING the north and south-seeking poles of a magnet using the known poles of another magnet.
MODULE 55 Observing/n
DESCRIBING forces acting on moving and nonmoving objects.
THIS MODULE Measuring/j
CONSTRUCTING diagrams showing the forces acting on moving and nonmoving objects.
THIS MODULE Measuring/j
IDENTIFYING balanced forces that operate on a stationary object and *DEMONSTRATING* with a spring scale that a force is needed to move an object on a horizontal surface.
MODULE 37 Measuring/f
DISTINGUISHING linear from nonlinear motion and *IDENTIFYING* and *NAMING* straight and curved paths on a plane surface.
MODULE 45 Using Space/Time Relationships/g
DEMONSTRATING a procedure for drawing an object to a given scale.
MODULE 47 Communicating/f

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II**, is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173

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RATIONALE

In *Using a Balance, Measuring d, Module 26,* the children learned to use the term *earth-pull* to describe what happens when an object is placed in one pan of a balance. This module reviews the concept of earth-pull, emphasizing that it is a downward force.

On the basis of their experience in *Forces, Measuring f, Module 37,* the children should be able to associate the amount of stretching of a rubber band or spring with the amount of force applied by earth-pull or by a pull in some other direction. In this module, the children need not measure forces quantitatively; the words *larger force, smaller force,* and *equal forces* are sufficient. In later science experiences, the children learn that forces can be measured, and that these measurements are frequently compared when objects and properties are measured.

Arrows may be used to represent forces. Arrows of the same length represent forces of equal magnitude. The direction of the arrow represents the direction in which the force acts.

Two major ideas are introduced in this module. The first idea is that when an object is at rest, that is, not in motion, any force that is being applied to that object is being balanced by a force that is equal in size and opposite in direction. For example, suppose there is a ring attached to a spring and you pull on the ring so that the spring is stretched (see Figure 1). The pull of the spring on the ring is equal to the pull of your hand on the ring. The two pulls, or forces, are in opposite directions.

The second major idea introduced in this module is that any change in the motion of an object is caused by an unbalanced force acting on the object. For example, if you let go of the ring attached to the spring, the ring will move away from you because the pull of the spring is no longer balanced by the pull of your hand (see Figure 2).

Vocabulary

force exert
earth-pull

INSTRUCTIONAL PROCEDURE

Introduction

Partially fill two identical cardboard boxes, such as shoeboxes, with a different number of blocks or books, so that the weights of the boxes are considerably different. Cover the boxes and tie them with string. Hold one box in each hand in such a way that you do not reveal which box is heavier. Ask the children to tell whether one of the boxes you are holding is heavier than the other, or whether both boxes weigh the same. The children will probably be unwilling to answer, but if they do, ask them to explain how they reached their decision. They should become convinced that there is no basis for their conclusion. They will probably specify what additional evidence is needed in order to make such an inference.

Now attach two identical springs to the strings around the boxes, and lift the boxes by gently pulling on the springs. Ask the children again to tell you whether one of the boxes you are holding is heavier, or whether the boxes weigh the same. The children should see that the heavier box is the one that has stretched the spring more. Your questions here must depend on the children's responses. Ultimately, the children should describe their observations by saying that the springs stretched until they could apply a force upward on the boxes equal to the downward earth-pull on the boxes.

Materials

Cardboard boxes, 2, identical, with covers
Books or blocks, several, to put in boxes
String, 1 ball (*Module 51*)
Springs, 2, strong (*Module 54*)

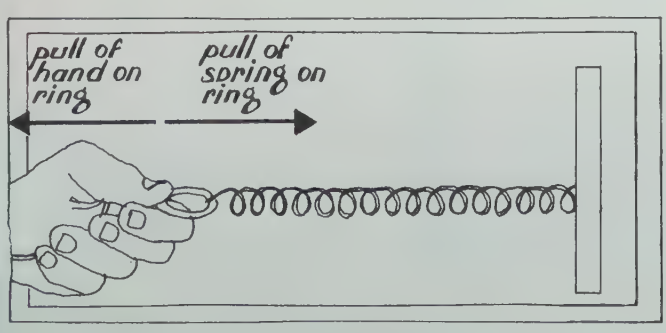

FIGURE 1

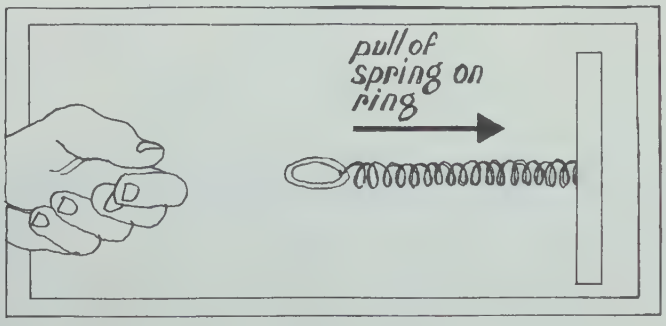

FIGURE 2

Activity 1

Divide the children into groups of four or five. Give each group a stick or pencil, two rubber bands, and several large washers, heavy enough to stretch the rubber bands. Ask the children to tie the rubber bands together and to slip the rubber bands through the washers and over the end of the stick or pencil (see Figure 3).

Ask the children questions such as the following:

Is there a force on the rubber bands at the point where the washers are hanging? (Yes.)

How do you know? (Because the rubber bands are stretched.)

What is the direction of the force of the washers on the rubber bands? (Down.)

What causes the downward force? (The washers.)

Discuss the idea that the earth pulls on the washers and the washers pull on the rubber bands.

Give each group a pair of scissors and suggest that they cut the rubber bands and observe what happens. (The washers fall.) Ask the children to describe the forces after the rubber bands were cut. (The rubber bands no longer pulled up on the washers. The earth pulled down on the washers, and the washers fell.)

Sketch Figure 4 on the chalkboard. Place the label *P* at the point where the rubber bands support the washers. The two arrows represent the forces on the washers. As you draw Arrow *A*, say that the earth pulls *down* on the washers. As you draw Arrow *B*, which should be the same length as *A*, say that the rubber bands pull *up* on the washers. You might explain that the arrows represent forces and since the forces are equal in size, the arrows are drawn having equal lengths. Say again that the force of the earth on the washers is down; the force of the rubber bands on the washers is up.

Referring to the sketch, ask the children questions such as the following:

Which is greater, the force of the earth down or the force of the rubber bands up, or are they the same? (They are the same.)

How could we tell if they were not the same? (The washer would move. If the children cannot answer this question, remind them that they have just seen a case in which the forces were not the same.)

When you cut the rubber band, you removed its force. (Erase the arrow representing the force of the rubber band.) What happened? (The washers fell.)

Materials

Rubber bands, 1 box (*Module 54*)
Large washers, 30 (*Module 54*)
Sticks or pencils, 7 or 8
Scissors, 7 or 8

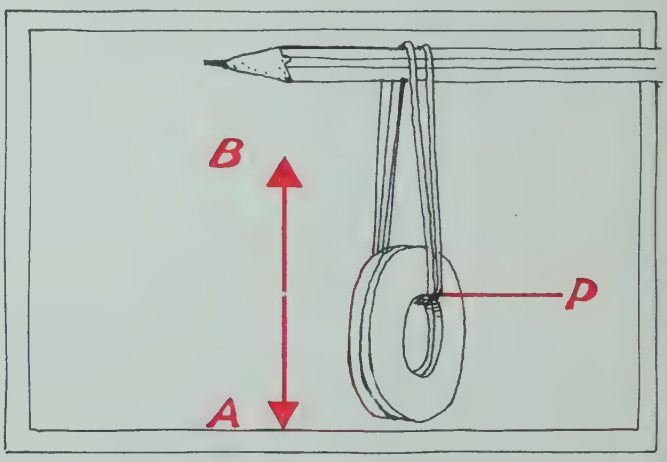

FIGURE 4

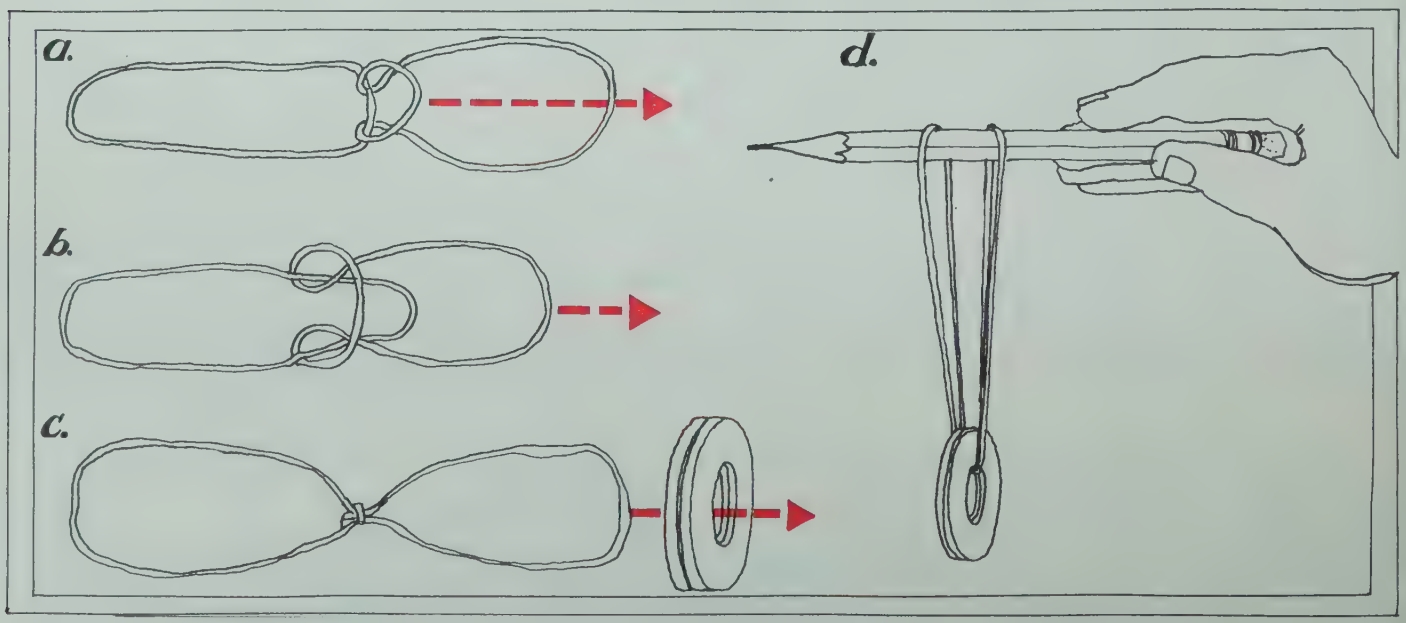

FIGURE 3

Activity 2

Support an object in your hand and stand as still as possible so there is no motion. Ask the children to describe the forces acting on the object. Then ask one of the children to diagram the forces with arrows on the chalkboard. During the discussion, this point should be emphasized: The upward force of the hand is equal to the downward force of earth-pull; therefore, the object is not moving.

What would happen if we removed one of the forces? (The object would move.) Remove your hand and let the object fall. Erase the arrow on the chalkboard corresponding to the upward force. Tell the children that when one of the forces is removed, the forces on the object are no longer balanced, and the object begins to move.

Divide the children into groups of four. Distribute five rubber bands, two paper clips, and a toy car to each group. Have each group make a chain with the rubber bands and attach one end of the chain to the front of the toy car with an opened paper clip (see Figure 5). Then have them attach the other end of the chain around the leg of a chair, or to the edge of the table with a paper-clip hook. Suggest that the children pull the car until the rubber bands are stretched and then let the car go.

Ask each child to draw two pictures of the car. Each picture should show with arrows the forces acting on the front of the car (Point *X* in Figure 5). Tell the children that the first picture should show the forces when the car is pulled so that the rubber-band chain is stretched, before the car is released. The second picture should show the forces after the car is released.

In one picture, the children should draw arrows of equal lengths to show the force exerted by the stretched rubber bands in one direction and the force exerted by the car and hand in the opposite direction. In the second picture, the children should show only the force exerted by the stretched rubber bands.

Materials

Object, 1, that can be held in the hand
Rubber bands, 1 box (*Module 54*)
Toy cars, 6 (*Module 54*)
Chairs with legs or tables, 1 for each group
Paper clips, 1 box
Drawing paper, 2 sheets for each child
Pencils, 1 for each child

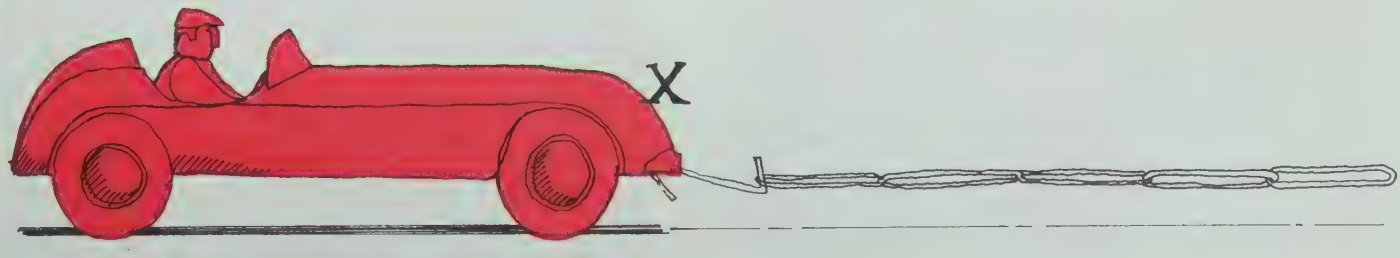

FIGURE 5

Generalizing Experience

Select two tug-of-war teams of three or four children each and give them a rope about 5 meters long. Tie a piece of string around the middle of the rope to make it easier for the rest of the children to see whether the rope is moving. Ask the teams to pull on the rope and to try to keep the rope from moving. Next, ask them to pull as hard as they can. One team will probably pull harder than the other and the children will see the string move.

Ask the children to draw pictures and to show with arrows the forces exerted by the two teams at the point where the string was tied. The picture should show the forces exerted when the rope was not moving (as shown by the equal arrows in Figure 6a). The other picture should show the forces when one team won the tug-of-war.

If Team *A* suddenly let go of the rope, Team *B* and the rope would move to the right. The single arrow in Figure 6b shows that only Team *B* is pulling on the rope.

Many of the children's activities and sports, such as baseball, soccer, or archery, will give you an opportunity to use the idea of forces acting on moving and nonmoving objects. Some teachers have used this module to introduce a discussion of rockets and space travel.

Materials

Rope, 1 piece, about 5 m
String, 1 ball (*Module 51*)
Drawing paper, 1 sheet for each child
Pencils, 1 for each child

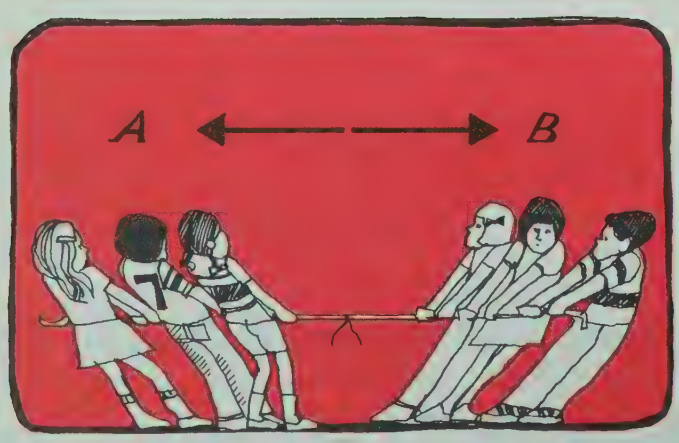

FIGURE 6a

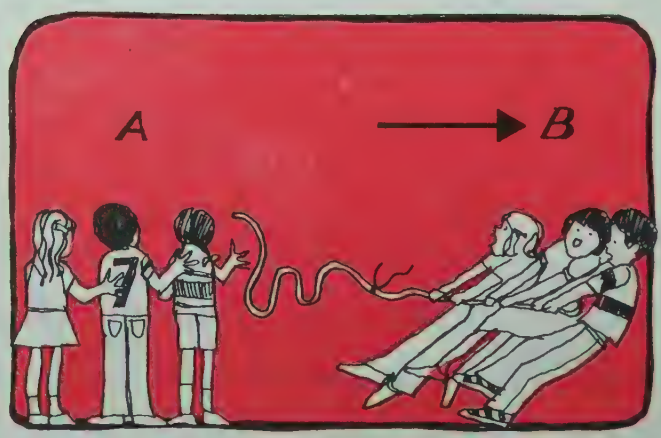

FIGURE 6b

APPRAISAL

Have one child stand on a chair so all the children can see. Have that child hold a pencil inserted through the top ring of a spring. Attach a tied cardboard box half full of blocks or books to the hook on the spring. Tell the children to draw the spring and box and to draw arrows to represent the forces acting on the point where the box is attached to the hook (Point I in Figure 7). Tell the children to label the arrows so that anyone else looking at the diagram would know what forces the arrows represent (earth-pull, the force of the spring, and so on). Their drawings should be similar to Figure 7.

Ask the children what would happen to the box if you opened it so the blocks or books suddenly fell out. Would the box move up, move down, or stand still? Have the children explain their answers either orally or in writing. They should use the word *force* in their explanations.

Materials

Spring, 1, strong (*Module 54*)
Pencil, 1, to support the spring
Chair, 1, to stand on
Cardboard box, 1
String, 1 ball (*Module 51*)
Books or blocks, several, to put in box
Drawing paper, 1 sheet for each child
Pencils, 1 for each child

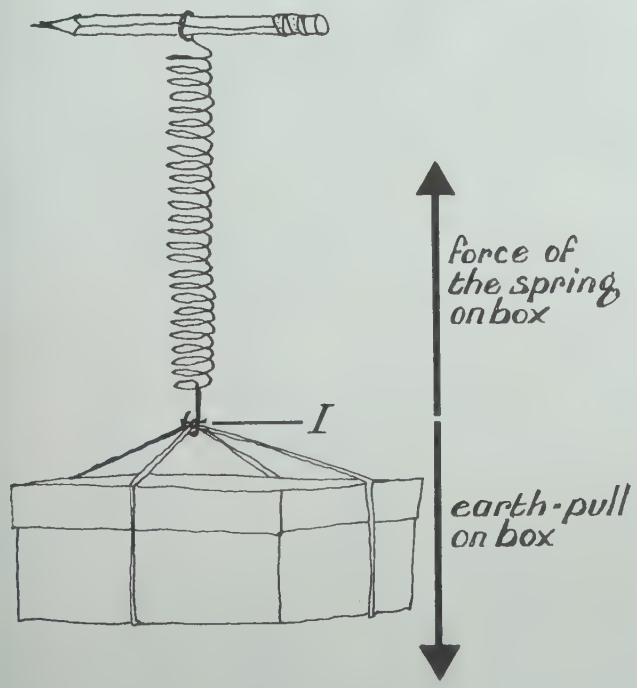

FIGURE 7

COMPETENCY MEASURE

TASK 1 (Objective 1): Put a washer on the dropping machine (see Figure 8) and ask, Why isn't the washer moving? The child should indicate that the force of the earth pulling down on the washer is equal to the force of the wire rod pulling up on the washer.

TASK 2 (Objective 2): Say, Watch what I am going to do. Pull the wire rod so that the washer falls. Ask, Why did the washer start to move? The child should indicate that the downward force on the washer was greater than the upward force, or that only the downward force was acting on the washer.

TASK 3 (Objective 3): Put a washer on the dropping machine. Indicate the point where the washer is touching the wire rod, and say, Draw a diagram with arrows to show what forces are acting right here. The child should draw two arrows of equal length in the correct directions, one for the earth-pull downward on the point and one for the pull of the wire rod upward on the point. If the child does not label the arrows, ask what force each arrow represents.

TASK 4 (Objective 3): Say, Watch what I am going to do. Pull the wire rod so that the washer falls. Repeat the procedure if necessary. Say, Change your diagram to show the force that is acting on the point just after I pull the handle. The child should eliminate the arrow representing the upward pull of the wire rod.

Materials

Dropping machine, 1
Washer, 1, large (*Module 54*)
Drawing paper, 1 sheet for each child
Pencils, 1 for each child, with eraser

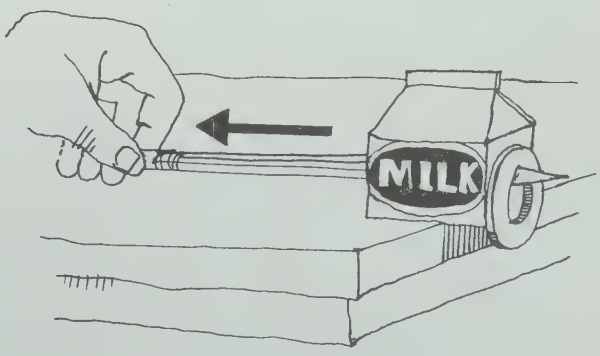

FIGURE 8

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54 Measuring/j

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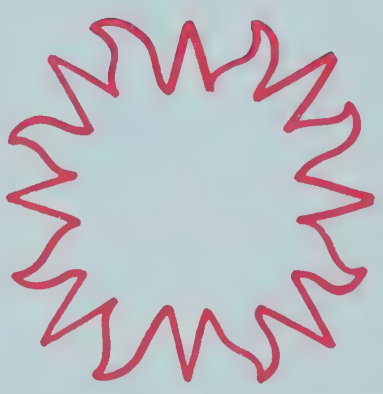

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SCIENCE... A PROCESS APPROACH II

MODULE
55

Observing/m and n

Sprouting Seeds Magnetic Poles

OBJECTIVES: Sprouting Seeds (Observing/m)

At the end of this module the child should be able to

1. *IDENTIFY* changes in growing plants from day to day.
2. *CONSTRUCT* a chart on which to show growth of plants from seeds.

OBJECTIVES: Magnetic Poles (Observing/n)

At the end of this module the child should be able to

1. *IDENTIFY* the north-seeking and south-seeking poles of a magnet using the known poles of another magnet.
2. *CONSTRUCT* an electromagnet.
3. *DEMONSTRATE* that a magnet has a magnetic field.

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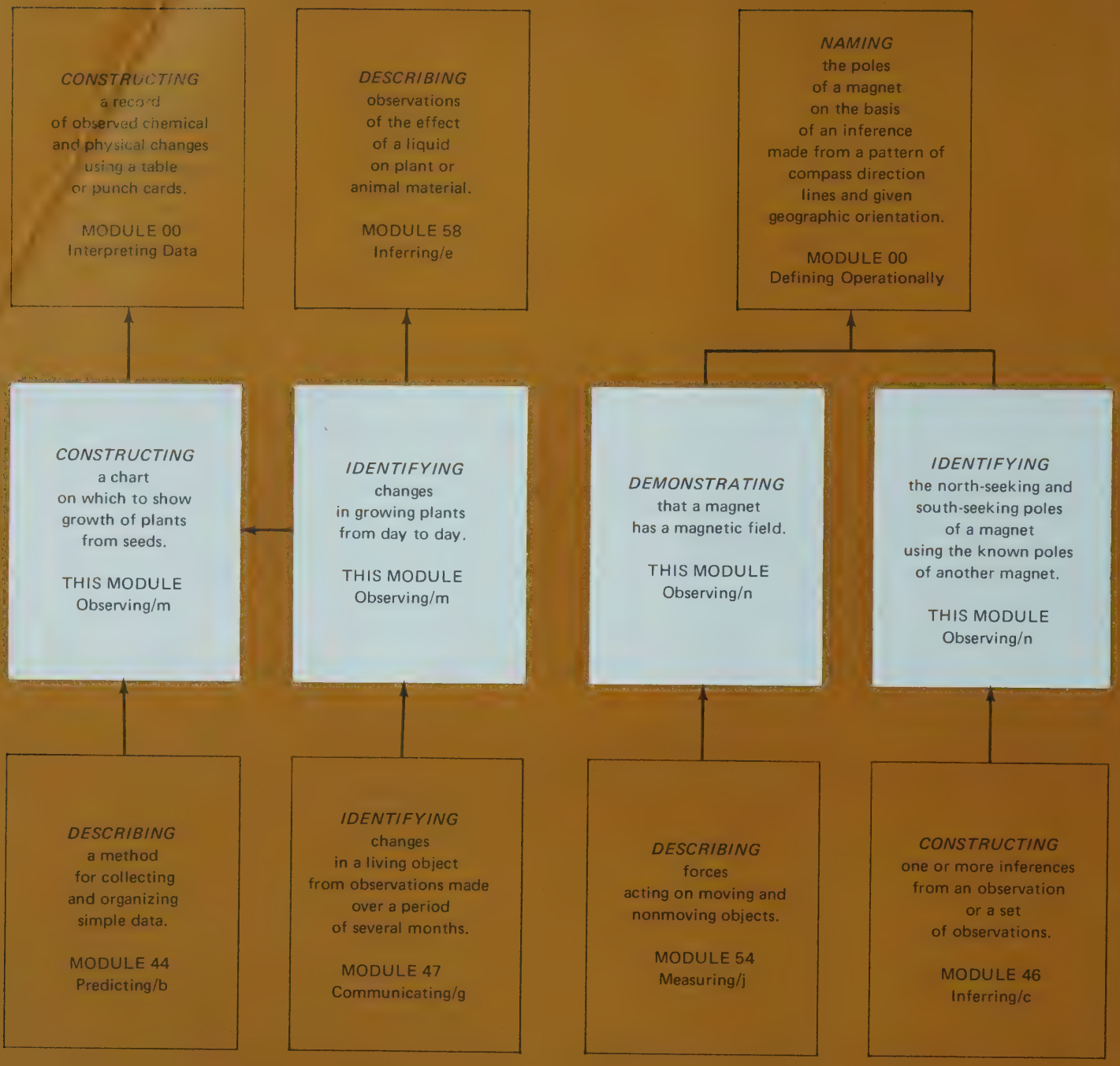
SEQUENCE


CONSTRUCTING a record of observed chemical and physical changes using a table or punch cards.
MODULE 00 Interpreting Data
DESCRIBING observations of the effect of a liquid on plant or animal material.
MODULE 58 Inferring/e
NAMING the poles of a magnet on the basis of an inference made from a pattern of compass direction lines and given geographic orientation.
MODULE 00 Defining Operationally
CONSTRUCTING a chart on which to show growth of plants from seeds.
THIS MODULE Observing/m
IDENTIFYING changes in growing plants from day to day.
THIS MODULE Observing/m
DEMONSTRATING that a magnet has a magnetic field.
THIS MODULE Observing/n
IDENTIFYING the north-seeking and south-seeking poles of a magnet using the known poles of another magnet.
THIS MODULE Observing/n
DESCRIBING a method for collecting and organizing simple data.
MODULE 44 Predicting/b
IDENTIFYING changes in a living object from observations made over a period of several months.
MODULE 47 Communicating/g
DESCRIBING forces acting on moving and nonmoving objects.
MODULE 54 Measuring/j
CONSTRUCTING one or more inferences from an observation or a set of observations.
MODULE 46 Inferring/c

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

This module has two sections, *Sprouting Seeds*, and *Magnetic Poles*, each emphasizing the process *Observing*. In the first section, the children observe the germination of seeds, and the growth of roots, stems, and leaves. In the second section the children observe some properties of magnets.

The activities in *Sprouting Seeds* are designed to help children observe and record growth patterns and some of the changes that occur in growing plants. After observing that different regions of roots, stems, and leaves do not all grow at the same rate, the children may want to know whether or not parts of other growing things develop at the same rate.

Before starting an activity, encourage the children to make inferences about what will happen. Most of them will probably infer that given certain treatment, all seeds will grow. Sometimes, they will also be able to say what kind of plant will result from a given seed. As this module progresses, the children will observe that some of their inferences are not valid. For example, the inference that all the seeds will germinate is wrong; the roasted seeds used in the *Introduction* will not germinate. Another wrong inference is that certain seeds that look alike will produce seedlings and plants that also look alike.

Because the seeds used in *Activity 2* germinate quickly, children may believe that this is true of all seeds. To change this misconception, children need experiences with seeds that have longer germination periods. One such experience is provided by the second experience in the *Generalizing Experiences.*

You may wish to have some children begin *Magnetic Poles* while waiting for their plants to grow. The three activities of this section are presented in an auto-instructional booklet that allows the children to work independently or in pairs. The first activity will be in part a review of *Pushes and Pulls, Communicating c, Module 27.* When a magnet is hung from a strand of thread, it points in a north-south direction. In this activity, the north-seeking end of the magnet is marked, and the child is able to observe that the magnet points in a north-south direction. In the second activity, the child makes an electromagnet by wrapping insulated copper wire around an iron bolt and connecting the ends of the wire to a dry cell battery.

The third activity shows the child that a magnet, including an electromagnet, has a magnetic field surrounding it. When a piece of paper is placed over a magnet and iron filings are sprinkled onto the paper, the filings become magnetized and line up along the lines of the magnetic field.

Vocabulary

germinate	north-seeking
germination	south-seeking
seedling	repel
plant	attract
stem	electromagnet
root	battery
emerge	battery holder
vermiculite	magnetic field

Advance Preparation

The *Appraisal* for *Sprouting Seeds* requires wheat seeds that were started germinating 1, 2, and 4 days previously. Start these at the appropriate times in the petri dishes that the children use during the *Appraisal.*

INSTRUCTIONAL PROCEDURE

Sprouting Seeds

Introduction

Put 16 petri dishes labeled from *A* to *P* on a table in view of all the children. Figure 1 lists the kinds of seeds to be placed in each dish. Then put at least ten seeds in each dish. Keep additional seeds of each kind in envelopes labeled as you labeled the petri dishes. Ask the children to tell you as much as they can about the contents of the petri dishes. You might direct their observations by asking questions, such as the following:

What do you see in the containers?

Are the seeds all alike? How are they different?

How does a seed look when it germinates?

Tell the children that they will have an opportunity to observe seeds germinating.

Set the petri dishes aside for use in *Activity 2.*

Materials

Petri dishes, 16 (*Module 55*)
Corn seeds, 1 pkg, dried (*Module 55*)
Radish seeds, 1 pkg of each kind: red and white (*Module 55*)
Bean seeds, 1 pkg of each kind: lima, wax, and mung (*Module 55*)
Sunflower seeds, 1 pkg of each kind: plain and roasted (*Module 55*)

Label on petri dish	Kind of seed
A – corn	dried corn
B – corn	dried corn
C – radish	red radish
D – radish	red radish
E – radish	white radish
F – radish	white radish
G – beans	lima bean
H – beans	lima bean
I – beans	wax bean
J – beans	wax bean
K – beans	mung bean
L – beans	mung bean
M – sunflower	sunflower
N – sunflower	sunflower
O – sunflower	roasted sunflower
P – sunflower	roasted sunflower

FIGURE 1

Activity 1

Give each pair of children a copy of the booklet *Germination Chamber* and the necessary materials. Tell the children that the booklet explains how to make something in which they can plant bean seeds and watch the seeds germinate. You may need to assist some children in cutting the paper cups. The germination chambers do not need to be placed in sunlight or artifical light until the bean plants have developed leaves. After growth starts, more light will be needed.

Start *Activity 2* as soon as the children have constructed their germination chambers. After the bean plants have started to grow, have the children begin *Activity 3* in which they continue to use the germination chambers.

Materials

Germination Chamber, 15 booklets (*Module 55*)
Paper cups, 30 (*Module 55*)
Plastic sheets, 10, flexible, transparent (*Module 55*)
(Note: Cut each sheet into 6 pieces each approximately 9 x 9 cm.)
Paper towels, 1 for each child
Transparent tape, 1 roll
Wax bean seeds, 60 (*Module 55*)
Scissors, 1 for each child
Metric rulers, 10, (*Module 47*)
Pencils, 1 for each child

Activity 2

Tell the children that they are going to plant the seeds that they observed and discussed in the *Introduction.* Try to get them to agree on a procedure to follow. You might ask them what to do first. Using their words, record their suggestions on the chalkboard, and question the order of the steps if necessary. A final list should include these steps:

1. Soak the seeds for 2 or 3 hours before planting.
2. Put vermiculite in the flower pot to about 3 centimeters from the top.
3. Put two or three seeds of one variety in each flower pot and cover them with more vermiculite so that the seeds are about 15 millimeters below the surface of the vermiculite. (3 centimeters below for the lima beans seeds). Do not press down the vermiculite.
4. Label the flower pots to identify the seeds and who planted them, and put the pots on a tray in a warm, light place.
5. Keep the vermiculite moist by adding water daily.

Before the children do any planting, discuss with them the kinds of changes they expect in the seeds. After several changes have been suggested, ask for ideas about ways to remember how the seeds look before they are planted and each time they are observed, so that each observation can be compared with previous observations. Children may suggest keeping a wall chart or individual charts. Ask them what kinds of observations could be recorded before the seeds are planted. Use their suggestions to begin a *Plant Observation Chart* as shown in Figure 2.

Give each pair of children two flower pots, a petri dish of seeds, and soaked vermiculite. Tell the children that they are going to plant the seeds in at least two flower pots. The children will be able to compare the growth of the single variety of seeds in the two flower pots. You might have the children plant dried peas or beans too, if you want them to have more experience with seeds that do not grow. Have the children record their observations about the seeds on the wall chart and then follow the agreed-upon procedure for planting the seeds.

When the recording and planting are completed, discuss with the children the changes they expect to see. Someone will probably suggest that plants will appear. Add a column to the *Plant Observation Chart* (see Figure 3).

	PLANT OBSERVATION CHART				
Code letter of seeds	What the seeds looked like			Date planted	
	Size	Color	Shape		
A					
B					
C					
D					
E					

FIGURE 2

	PLANT OBSERVATION CHART				
Code letter of seeds	What the seeds looked like			Date planted	Date plant emerged
	Size	Color	Shape		
A					
B					
C					
D					
E					

FIGURE 3

After the plants emerge, ask what other changes may occur as the plants grow. Use the children's suggestions to extend the *Plant Observation Chart.* Figure 4 shows one possibility.

After a growing period of a few days, enough data should be present on the *Plant Observation Chart* for some analysis. A study of the data may indicate the following:

1. Not all of the plants appeared at the same time.
2. The plants did not all look the same as they emerged through the vermiculite.
3. Some plants grew faster than others.
4. The plants were not all the same color when they emerged through the vermiculite.
5. Some seeds did not develop into plants.

These observations will show the children that some of the inferences that they made earlier about how the seeds would germinate may have been wrong. Ask the children to examine samples of each kind of seed they planted. A close comparison of the sunflower seeds that did grow with those that did not may reveal that those that did not grow had been roasted first. You may have to tell the children that this is what had been done. They may also discover that although the red and white radish seeds look alike, their plants are different.

The children should also see that seedlings can be quite different in other ways. For example, some of the plants are very light in color, or white, instead of green. Emphasize that we cannot tell by looking at a seed exactly what it will produce or even whether it will grow. Remind the children, too, that seeds may look alike but produce very different plants.

Using the *Plant Observation Chart* during this discussion will help the children to realize the importance of recording observations in an organized fashion so that data can be compared.

Materials

Shelf paper or newsprint, for making wall chart
Marking pen, 1
Flower pots, 30 (*Module 55*)
Vermiculite, 1 bag (*Module 55*)
(Note: Soak the vermiculite overnight before giving it to the children.)
Petri dishes with seeds, 15, from *Introduction*
Tray, 1

PLANT OBSERVATION CHART

Code letter of seeds	What the seeds looked like			Date planted	Date plant emerged	Height in centimeters on day					Color of plant on day				Description of leaves
	Size	Color	Shape			1	2	3	4	5	1	2	3	4	
A															
B															
C															
D															
E															

FIGURE 4

Activity 3

After the bean plants in the germination chambers begin to grow, ask the children how they can show that the plants are actually growing. They should make and record observations of the stem and root similar to those they are making with their plants in *Activity 2*.

Discuss the growth rate of the stem as compared to the growth rate of the root. Since the root appears first, the children will probably conclude that the growth rate of the root is much faster than the growth rate of the stem. Ask them to continue recording measurements for several more days. Eventually the length of the stem will surpass the length of the root.

After the roots of the bean plants have reached a length of 5 centimeters, ask the children where they think the growth of the root is occurring. Some may say that the growth is occurring at the tip. Some may say that the growth is occurring in the middle, and others may say the growth is occurring near the seed. Have the children remove the germination chamber from the container of water and carefully lift the plastic sheet covering the seeds. Have them mark the root of the bean seedlings at 1-centimeter intervals by applying the ink and margarine mixture with a toothpick. (See Figure 5.) Assign a letter to each segment to make communication about observed growth easier. Have the children replace the plastic sheet over the seeds and tape it down.

Have the children measure and record the length of each segment for three or four days. Some of the segments on the root should be growing faster than others. After a few days, children will probably notice that some of the root segments have "spurs," as shown in Figure 6. Have them record the day this is first observed. Since measuring and recording the lengths of the segments is inadequate for determining where all growth is occurring, discuss with the children ways to record additional changes. They may suggest making written descriptions and/or diagrams as well as recording the linear measurements of the segments.

Continue this activity for about five days, having the children record their observations each day. To make record keeping meaningful, be sure to discuss how the root looks "today" as compared to the way it looked three days ago, or yesterday.

After completing *Activity 3*, the children will probably wish to watch their plants grow to maturity. If you choose to let them do this, provide them with soil and discuss the necessary steps to follow for potting their plants.

Materials

Germination chambers, from *Activity 1*
Ink, 1 bottle, black indelible
Margarine, 1 ml
(Note: For the ink and margarine mixture, mix two or three drops of ink with the margarine.)
Toothpicks, 1 box (*Module 55*)
Metric rulers, 10, (*Module 47*)

FIGURE 5

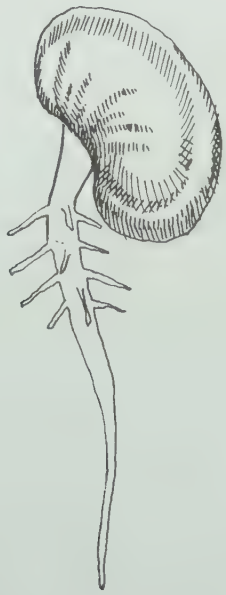

FIGURE 6

Generalizing Experiences

You may wish to choose either experience *1* or *2*.

1. During language arts have the children write letters to friends and relatives telling them that the class is studying seeds and how they grow, and asking them for seeds from one or more plants common in their part of the country. The children might also ask for helpful hints on how to plant the seeds and how to care for the plants that may result from the seeds.

After some seeds have been received, have the children identify on a commercial map, or one prepared by the children, the locations from which seeds have been received. Relate the plants that produced the seeds to the economy, weather, and soil of the location. This activity might be incorporated into a social studies lesson.

Then, during science, plant the seeds as directed by the senders or as indicated from the map study in social science. You may wish to have the children put some of each type of seed in a small plastic bag and attach the bags to the map or make a bulletin board display. For a bulletin board display, the seeds could be grouped in many different ways, such as by geographic region, climate best suited for growth, how they are spread, or which, if any, animals consume them.

2. Ask the children to bring in seeds different from those used in *Activity 2*. Suggest that they bring seeds from an orange, a grapefruit, an apple, an avocado, and other common fruit. Use procedures similar to those described in *Activity 2* so that observations may be shared.

This activity will extend over a long period of time. After some of the seeds have been planted, proceed with the *Appraisal* and *Competency Measure*.

Materials

Writing paper, 1 sheet for each child
Envelope, 1 for each child
Seeds, sent to the children
Map, appropriate to location from which seeds have been sent
Flower pots, 15 (*Module 55*)
Vermiculite, 1 bag (*Module 55*)
Plastic bags, several
Seeds, brought in by the children

INSTRUCTIONAL PROCEDURE

Magnetic Poles

Introduction

This section of the module consists of three activities in an auto-instructional booklet. The children can take as long as they wish to complete the activities. The booklet is accompanied by a box of materials needed for the activities. You might wish to fill the box with the materials needed for each activity before the children begin that activity, or you might prefer to have the children keep all the materials in the box.

Before the children begin to use the booklet *Magnetic Poles,* briefly discuss the project with them. Instruct the children to use the booklets on their own, and not to mark in them. Tell the children to stop and return both the booklets and boxes to you each time they read that direction.

Activity 1

Before the children begin the activity, hang two pieces of thread from some high place, such as a doorway or the ceiling, and attach a clothespin to each thread as shown in *Activity 1* of the booklet. The clothespins should be about as high as a child's head and about 1 meter apart. Hang a bar magnet from one of the clothespins as shown in the booklet. After the magnet has stopped moving, hold a compass 30 centimeters below it. The magnet should be pointing in a north-south direction. Mark an "N" on the north-seeking end of the magnet with a piece of masking tape.

Provide the child with the booklet *Magnetic Poles,* a copy of *Magnet Poles Answer Sheet,* a magic pen, and the collection of items described in *Materials.*

Materials

Thread, 1 spool
Clothespins, 2 (*Module 55*)
Compass, 1 (*Module 55*)
Masking tape, 1 small piece
Magnetic Poles, 5 booklets (*Module 55*)
Magnetic Poles Answer Sheet, 1 spirit master (*Module 55*)
Magic pens, 5, image developers (*Module 59*)
Items to accompany each booklet
- Box, 1 (*Module 55*)
- Bar magnets, 2 (*Module 55*)
- Non-magnetic bar that looks like a magnet, 1 (*Module 55*)
- Metric ruler, 1 (*Module 47*)
- Paper clips, 10
- Variety of other small metal objects, such as paper fasteners and metal rods

Activity 2

Provide the child with the booklet *Magnetic Poles*, a copy of *Magnetic Poles Answer Sheet*, a magic pen, and the collection of items described in *Materials*.

After the children complete *Activity 2* they should bring their electromagnets to you. Check the electromagnets to see that they are made correctly. The wire should be wound evenly around the bolt so that each coil touches the next but does not overlap it. Put the electromagnets aside. The children will come for them when they are working on *Activity 3*.

Materials

Magnetic Poles, 5 booklets (*Module 55*)
Magnetic Poles Answer Sheet, 1 spirit master (*Module 55*)
Magic pens, 5, image developers (*Module 59*)
Items to accompany each booklet
- Box, 1 (*Module 55*)
- Dry cell battery, 1
- Battery holder, 1 (*Module 55*)
- Bolt, 1 (*Module 55*)
- Insulated wire, 1 coil (*Module 55*)
- (Note: Cut the wire provided into 2.1 m segments and peel off the insulation 1 cm from each end.)

Iron filings, 1 container (*Module 55*)
Metric ruler, 1 (*Module 47*)
Staples, several

Activity 3

Provide the child with the booklet *Magnetic Poles*, a copy of *Magnetic Poles Answer Sheet*, a magic pen, and the collection of items described in *Materials*.

Materials

Magnetic Poles, 5 booklets (*Module 55*)
Magnetic Poles Answer Sheet, 1 spirit master (*Module 55*)
Magic pens, 5, image developers (*Module 59*)
Items to accompany each booklet
- Box, 1 (*Module 55*)
- Bar magnets, 2 (*Module 55*)
- Non-magnetic bar that looks like a magnet, 1 (*Module 55*)
- Iron filings, 1 container (*Module 55*)
- Writing paper, 1 sheet
- Magnets, several (*Module 55*)
- Electromagnet, 1, constructed during *Activity 2*

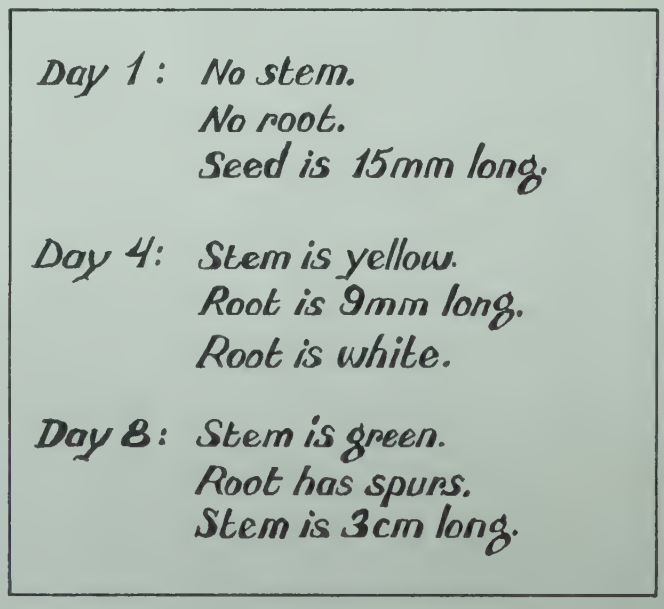

FIGURE 7

APPRAISAL: Spouting Seeds

Give each child the top or bottom half of a petri dish containing four germinating wheat seeds on damp paper toweling. The germination stages of each of the seeds should be different:

Seed	Time when seed was placed on damp toweling
1	Just before beginning the *Appraisal*
2	24 hours before beginning the *Appraisal*
3	48 hours before beginning the *Appraisal*
4	96 hours before beginning the *Appraisal*

Ask the children to record three observations to describe each seed. The recorded observations may be measurements, written descriptions, or diagrams.

After the children have recorded their observations, ask them to construct a chart that will make it possible to compare the descriptions systematically. There are many ways to do this. Accept any chart design that accomplishes the purpose.

Materials

Wheat seeds, 4 for each child (*Module 55*) at different germination stages
Petri dishes, 15 (*Module 55*)
Paper towels, 30 pieces
Writing paper, 1 sheet for each child
Pencils, one for each child
Metric rulers, 10 (*Module 47*)

COMPETENCY MEASURE: Sprouting Seeds

TASK 1 (Objective 1): Give the child the picture card entitled *Germinating Corn Seed* and say, **Here is a picture that shows growth from one corn seed. Between which days did the roots start to branch out?** The child should say between Day 3 and Day 5.

TASK 2 (Objective 2): Give the child a sheet of paper and a pencil. Show him the list of observations in Figure 7 and read them to him. Say, **Make a chart that presents these observations.** The child should construct a chart and the headings should include at least three of the following: color of stem, size of stem, color of root, size of root, size of seed, description of stem and seed.

Materials

Writing paper, 1 sheet
Pencil, 1

COMPETENCY MEASURE: Magnetic Poles

TASK 1 (Objective 1): Give the child a horseshoe magnet and a bar magnet with marked poles. Say, Find the north-seeking pole of the horseshoe magnet by using the marked bar magnet. The child should use the south-seeking pole of the bar magnet to find where the strongest attraction is on the horseshoe magnet and identify that as the north-seeking pole. Or the child might use the north-seeking pole of the bar magnet to find the point of greatest repulsion on the horseshoe magnet.

TASK 2 (Objective 2): Place in front of the child a collection of objects that includes the materials necessary for the construction of an electromagnet. Say, Find the parts necessary to make an electromagnet and build it. The child should select the dry cell battery, battery holder, bolt, and insulated wire, and construct an electromagnet.

TASK 3 (Objective 3): Give the child some iron filings, a piece of paper, and a bar magnet. Say, Use all of these materials and the electromagnet that you made to demonstrate a property of magnets, and tell it to me. The child should use the iron filings to show that a bar magnet has a magnetic field, and then use the filings again to show that an electromagnet has a magnetic field.

Materials

Horseshoe magnet, 1 (*Module 55*)
Bar magnet, 1, with poles marked (*Module 55*)
Collection of objects, including a bar magnet (*Module 55*), a piece of string, and paperclips
Dry cell battery, 1
Battery holder, 1 (*Module 55*)
Bolt, 1 (*Module 55*)
Insulated wire, 2.1 m (*Module 55*)
(Note: Check that the insulation has been peeled off 1 cm from each end.)
Iron filings, 1 container (*Module 55*)
Writing paper, 1 sheet

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55 Observing/m and n

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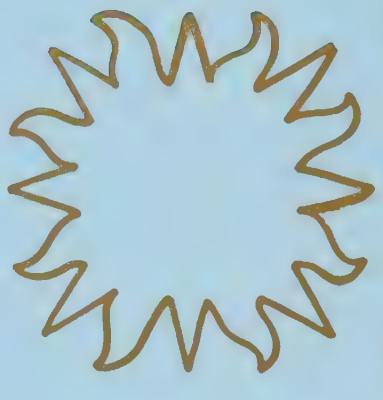

A PROCESS APPROACH II

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SCIENCE... A PROCESS APPROACH II

MODULE

56

Classifying/f

Punch Cards

OBJECTIVES

At the end of this module the child should be able to

1. *CONSTRUCT* a classification of objects into subsets.
2. *CONSTRUCT* a punch-card system to record simple data.
3. *DEMONSTRATE* the use of a punch-card system.

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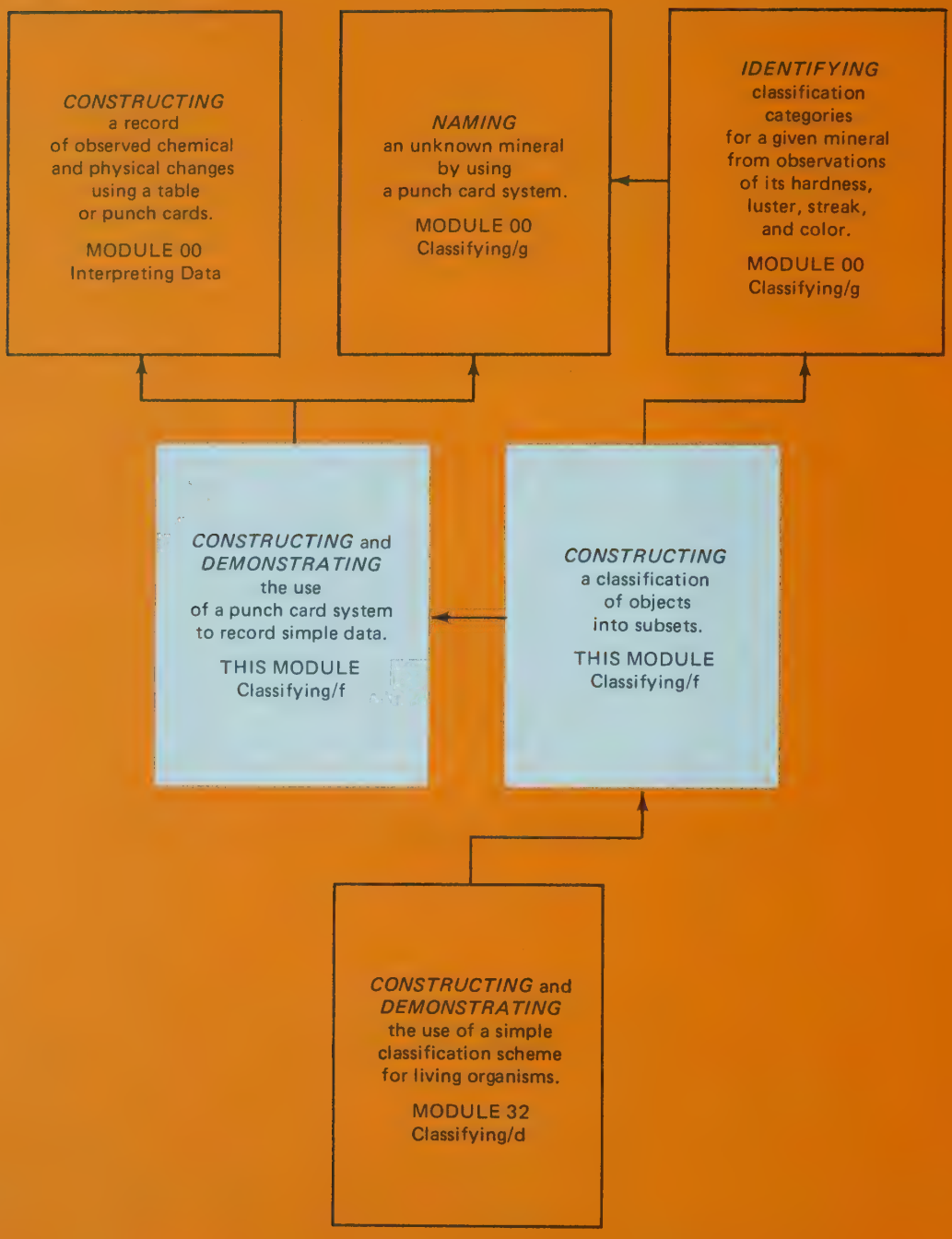
SEQUENCE


CONSTRUCTING a record of observed chemical and physical changes using a table or punch cards.
MODULE 00 Interpreting Data
NAMING an unknown mineral by using a punch card system.
MODULE 00 Classifying/g
IDENTIFYING classification categories for a given mineral from observations of its hardness, luster, streak, and color.
MODULE 00 Classifying/g
CONSTRUCTING and *DEMONSTRATING* the use of a punch card system to record simple data.
THIS MODULE Classifying/f
CONSTRUCTING a classification of objects into subsets.
THIS MODULE Classifying/f
CONSTRUCTING and *DEMONSTRATING* the use of a simple classification scheme for living organisms.
MODULE 32 Classifying/d

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

This module introduces a punch-card system for recording characteristics used to classify objects into subsets. It builds on skills developed in previous modules in which the children learned to classify objects according to their observable characteristics. Punch cards provide an orderly and easy system for recording and recovering information. Punch cards of various types are used widely in social research, business, government, education, and all branches of science.

In *Activity 1*, the children prepare their first set of punch cards. Six *yes* and *no* questions are used to classify the children in the room according to easily defined characteristics. If the answer to a question is *yes*, the children cut out a notch between the hole and the edge of the punch card. Help the children recognize that a negative answer to a question such as *Are you a boy?* must be a positive answer to the question *Are you a girl?* Eventually the children ask whether some pupils have two or more characteristics in common with other children. They may find that many, few, or even none do.

Activity 2 gives the children an opportunity to make additional sets of punch cards on their own. In *Activity 3* each child selects a tree to observe and records some of its characteristics on a punch card. The children develop inferences based on their observations, and make graphs of the data collected.

Vocabulary

punch card	to store information
characteristic	

INSTRUCTIONAL PROCEDURE

Introduction

Tell the children that you would like to group them in such a way that each group will share the same characteristic. For example, the characteristic might be "likes baseball" or "has brown eyes." Ask the children to suggest other characteristics that are shared by some children and not by others. The characteristics they suggest should be reasonably well distributed among the children and one characteristic should not be just the opposite of another. Select six characteristics from those suggested and list them as questions on the chalkboard. Leave the questions in place until *Activity 1* is completed.

The list might include some of the following questions:

Are you a girl?
Do you have a pet?
Do you have brothers?
Do you know how to swim?
Were you born on or between January 1 and June 30?
Is your birthday on or between the first and fifteenth of the month?
Is the school in the city or town where you were born?
Do you like chocolate ice cream?
Do you wear glasses?

Ask the children to go to designated places in the room as you name two or three characteristics from the list. For example, you could have the boys who know how to swim go to the left rear corner of the room, and the girls who have a brother and like chocolate ice cream go to the right rear corner of the room.

Continue until all the children are in some group. Allow the children to change groups if the designation of a new group also applies to them. For example, John may be in the group of boys who know how to swim, but he also fits into the group of those who have pets and among those who were born on or between January and June. When several children have moved from one group to another, point out that an object with many characteristics can be classified in many ways, and that if you want to remember how a group is made up, you have to record or "store" the information. Ask the children to think about ways in which information can be stored.

Activity 1

Ask the children if they have thought of ways to record and recover information about the members of the groups that were formed in the previous activity. If no one suggests it, ask how a set of cards, one card for each child, could be used so that information about the children could be found without having them move into groups. Their suggestions might include recording, on the card, the name of the child and the six characteristics that are listed on the chalkboard, and using a color code or some other classifying device to indicate the presence or absence of the characteristics.

Give the children punched index cards and have them write their names at the top and label the holes *A*, *B*, *C*, *D*, *E*, and *F*. Draw a sample card on the chalkboard. (See Figure 1.) Ask the children to write on the card the six characteristics listed on the chalkboard and to assign a letter to each. Suppose that Hole *A* represents the question *Are you a girl?* Ask the children to cut out a notch between the hole and the edge of the card, if the answer to the question is *yes*, but to make no cut if the answer is *no.* The girls should cut out a notch at Hole A and the boys should leave Hole A uncut. The cards will be easier to sort if the notch is cut in a V-shape.

Have the children cut notches to record the other data about themselves and hand the cards to you as they finish. So that there will be several sets of cards to sort, you may wish to have each child make several duplicate cards.

Arrange the cards so that all the names are at the top and facing the same way, then shuffle the cards. Keep the holes aligned. Hand the deck of cards to one of the children and ask the child to find all the cards belonging to girls as quickly as possible. If the child sorts them by hand, say that there is a faster way. Reassemble the cards, insert a rod into Hole A, lift, and allow the cut cards to fall out. The cards that fall out belong to girls; the ones that remain on the rod belong to boys. This technique can be used to sort the cards into subsets of which the members of each set share any characteristic or combination of characteristics.

Now ask the children to choose several characteristics from among the six listed on the cards. Ask a child to sort the cards in the way demonstrated to see how many children have the set of characteristics chosen. The child should put rods into all the holes for the characteristics chosen and shake the pack of cards. The cards of all children who have these characteristics will fall out. Explain that some rods can be eliminated to obtain certain kinds of subsets. For example, you could leave out the boy/girl selection to see how many children share a characteristic regardless of sex. In this case, a rod should not be put into Hole A.

Demonstrate how to make additional kinds of subsets. The subsets might be developed from the questions listed on the chalkboard during the *Introduction*. For example, select the cards belonging to the children whose birthdays are in the last half of the year and after the fifteenth of the month; the cards of children in this group will stay on the rods. Ask the children why this is so.

Encourage small groups of children to work with the cards during their free time, making sets of cards having characteristics they choose. Each child should have experience using the rods with the pack of punched cards.

Materials

Index cards, 90, punched (*Module 56*)
Scissors, 1 for each child
Rods, 30 (*Module 56*)

(Note: Straightened paper clips, knitting needles, small paint brushes, crochet hooks, straight segments of a metal coat hanger, or nails may be used if more rods are needed.)

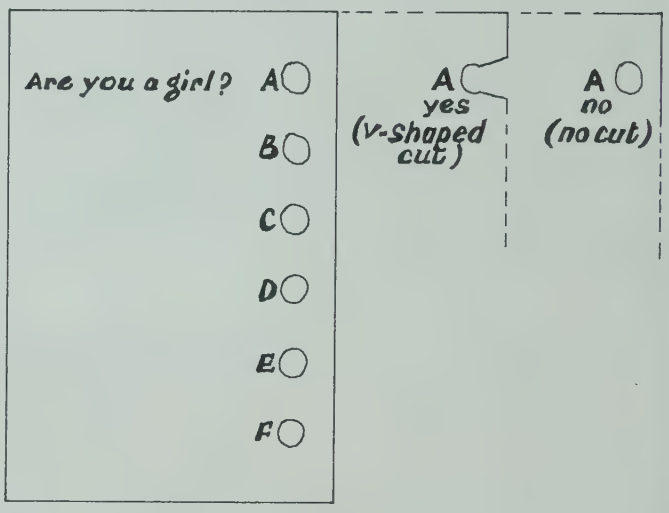

FIGURE 1

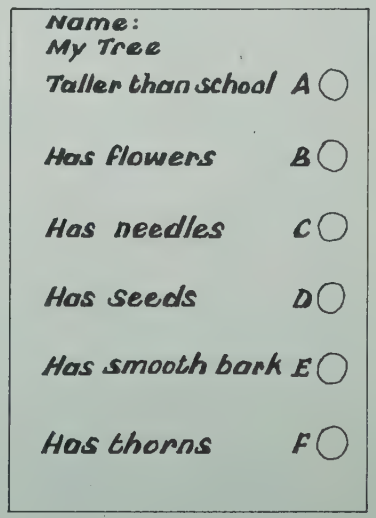

FIGURE 2

Activity 2

Repeat *Activity 1*, having the children make a new set of cards having a new list of characteristics. Give each child a list of characteristics and an opportunity to sort the pack of cards by using the rods. Have the child keep a record of his or her results to compare with others who have used the same list of characteristics.

Materials

Index cards, 90, punched (*Module 56*)
Scissors, 1 for each child
Rods, 30 (*Module 56*)

FIGURE 3

Activity 3

Ask each child to select a tree on the school grounds, in the neighborhood, or in a wooded area near the school. Have the children observe very carefully the trees they have chosen and the environments of the trees. Their observations should include such things as texture and color of bark, and symmetry and luster of leaves. If the children are keeping a *Tree Diary*, for *Module 47*, they can obtain information for punch cards in this activity from the diary.

When discussing their observations, encourage the children to make appropriate inferences. You might ask questions such as, "Can you infer why your tree has thorns?" or, "Can you infer how your tree may have acquired the scar or cut on its trunk?" The children should form questions similar to the following:

Is the tree taller than the school building?
Does the tree have flowers or buds?
Does the tree have needles?
Does the tree have seeds?
Is the bark smooth?
Does the tree have thorns?

The children may have other questions that apply more appropriately to the trees they are observing.

Give the children punched index cards and have them write their names at the top and label the holes *A*, *B*, *C*, *D*, *E*, and *F*. Have the children fill in their cards as you fill in the sample on the chalkboard. (See Figure 2.)

Have each child make a V-shaped cut next to each characteristic that his tree possesses. Collect all the cards when the children are finished. Suggest that the children compile the information about the trees by using rods to sort the cards into groups. Call on different children to do the sorting; have others ask them questions such as, "How many trees have seeds and are taller than the school building?" Let the children choose the characteristics to be used in the sorting.

Record the data next to the characteristics listed on the chalkboard. Discuss the data. Then ask the children if they know of another way to represent the data. They may suggest making a graph.

Give each child a sheet of graph paper on which to graph the data listed on the chalkboard. Their graphs may be similar to the one in Figure 3 on the next page.

You can repeat this activity changing the characteristics listed on the punch cards to "animals that live in the tree," "plants or animals that live under the tree," or "tree injuries," for example.

Materials

Index cards, 30, punched (*Module 56*)
Scissors, 1 for each child
Rods, 30 (*Module 56*)
Graph paper, 1 spirit master (*Module 56*)

Activity 4 (Optional)

Select an area having a boundary, such as a park, playground, or woods. Have the children examine every tree in the area for five or six pre-selected characteristics, and record the data on punched cards as in *Activity 3*. The cards can then be grouped in a variety of ways. The children should become aware of some relationships among the trees and the general environment that may not have been readily apparent.

Materials

Index cards, 30, punched (*Module 56*)
Scissors, 1 for each child
Rods, 30 (*Module 56*)

Generalizing Experience

Have each of several small groups work with a Shapagram try to construct a rectangle. After a few days ask how many children were able to fit the pieces of the puzzle together to make a rectangle. If any of the children were successful ask then how long it took them to find a solution and whether they can do it again. They will probably have difficulty remembering the relationship of the pieces to each other.

Tell the children that when this puzzle was created the clues were recorded on punch cards. Make the sets of Shapagram Clues and the Instruction Sheets available to the children. The clues in combination with the instructions provide solutions for the construction of Rectangles I, II, and III. These three solutions and many others are illustrated in Figure 4. After the children have had opportunities to use the cards, discuss ways the cards were useful. Someone should suggest that the cards made possible the storage of the solutions so they would not have to be remembered.

You might wish to tell the children that many other solutions exist for the Shapagram. Challenge them to find a new solution and then store the solution on punched cards so that another child may use it.

Materials

Shapagrams, 6 puzzles, each with an instruction sheet (*Module 56*)
Shapagram Clues, 3 sets of punch cards (*Module 56*)
Index cards, 20, punched (*Module 56*)
Scissors, 1 for each child
Rods, 30 (*Module 56*)

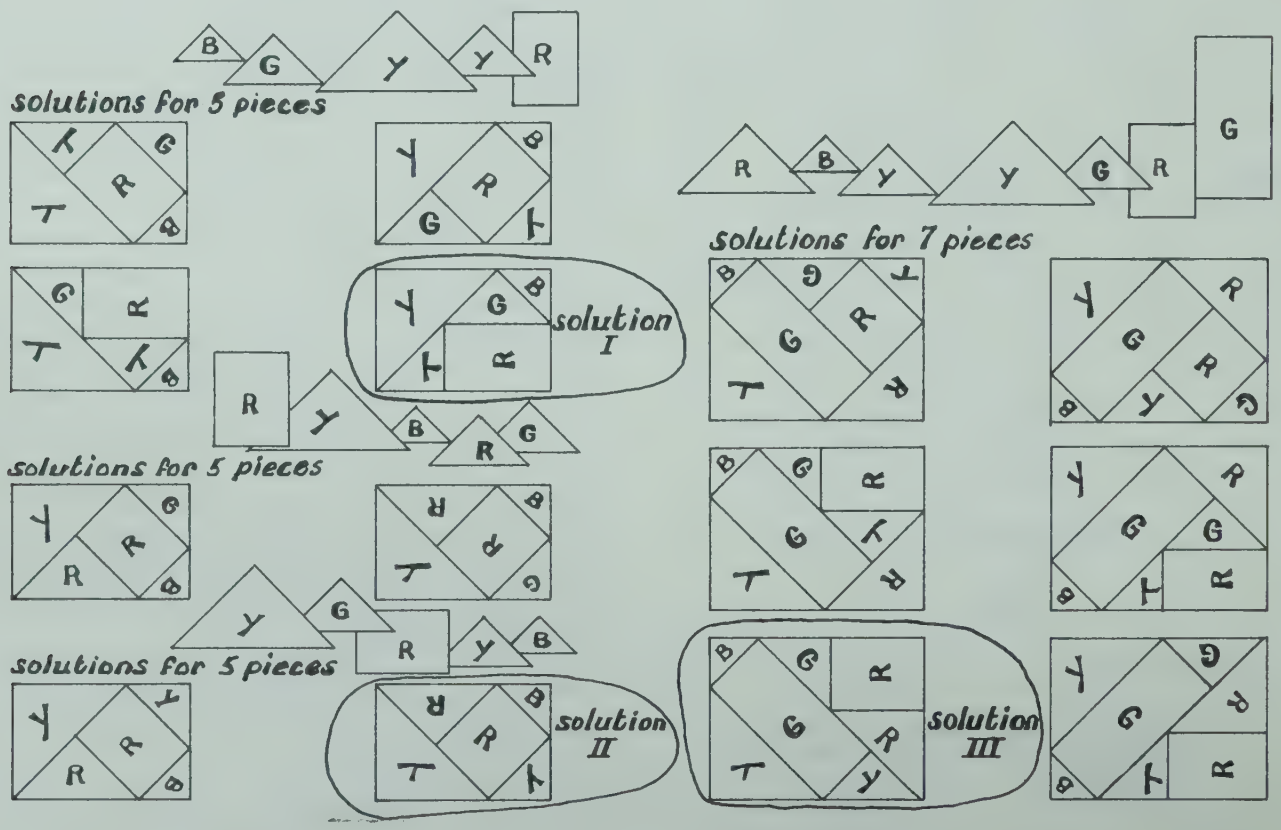

FIGURE 4

APPRAISAL

Ask the children to devise a punch-card system for recording the following information about animals.

Can or cannot fly
Has fur or does not have fur
Has feathers or does not have feathers
Has legs or does not have legs
Is taller (or longer) than a meter, or shorter than a meter
Lives in water or does not live in water

Have pairs of children prepare sets of punch cards to record this information about some of the following animals and any others they wish to add.

Bear	Whale
Goldfish	Ostrich
Turtle	Giraffe
Robin	Butterfly
Bat	Earthworm
Guinea pig	Snake

Ask the children to consider only adult animals. After two children have practiced using their own set, let them exchange sets with another pair of children to compare the information stored.

Materials

Index cards, 200, punched (*Module 56*)
Scissors, 1 for each pair of children
Rods, 15 (*Module 56*)

COMPETENCY MEASURE

Display the wall chart *Nine Trees* and give the child two rods and at least 9 cards each punched with six holes.

TASKS 1, 2 (Objectives 1, 2): Say, Make a system of punch cards for classifying the information contained in the pictures of the nine trees. The child should make a reasonable classification system based on the characteristics included in these questions:

Does it bear fruit?
Does it have needles on it?
Is it higher than 20 meters?

The child should mark and cut the punch cards according to his classification system.

TASK 3 (Objective 3): Name two of the characteristics listed by the child, for example, "trees that have needles and are over 20 meters tall." Then say, Use your punch-card system to find the trees that have both of these characteristics. The child should use the rods to sort out the appropriate cards.

Materials

Nine Trees, 1 wall chart (*Module 56*)
(Note: You may wish to cut the chart into 9 cards.)
Index cards, 9 for each child, punched (*Module 56*)
Scissors, 1
Rods, 2 (*Module 56*)

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SCIENCE... A PROCESS APPROACH II

MODULE

57

Communicating/h

Position and Shape

OBJECTIVES

At the end of this module the child should be able to

1. *IDENTIFY* and *NAME* positions on a map.
2. *CONSTRUCT* a map of an area to scale.
3. *NAME* the ordered number pair that locates a position on a map or grid.
4. *IDENTIFY* the position of an ordered number pair on a map or grid.
5. *CONSTRUCT* drawings of regular, three-dimensional shapes and of objects that exhibit these shapes.

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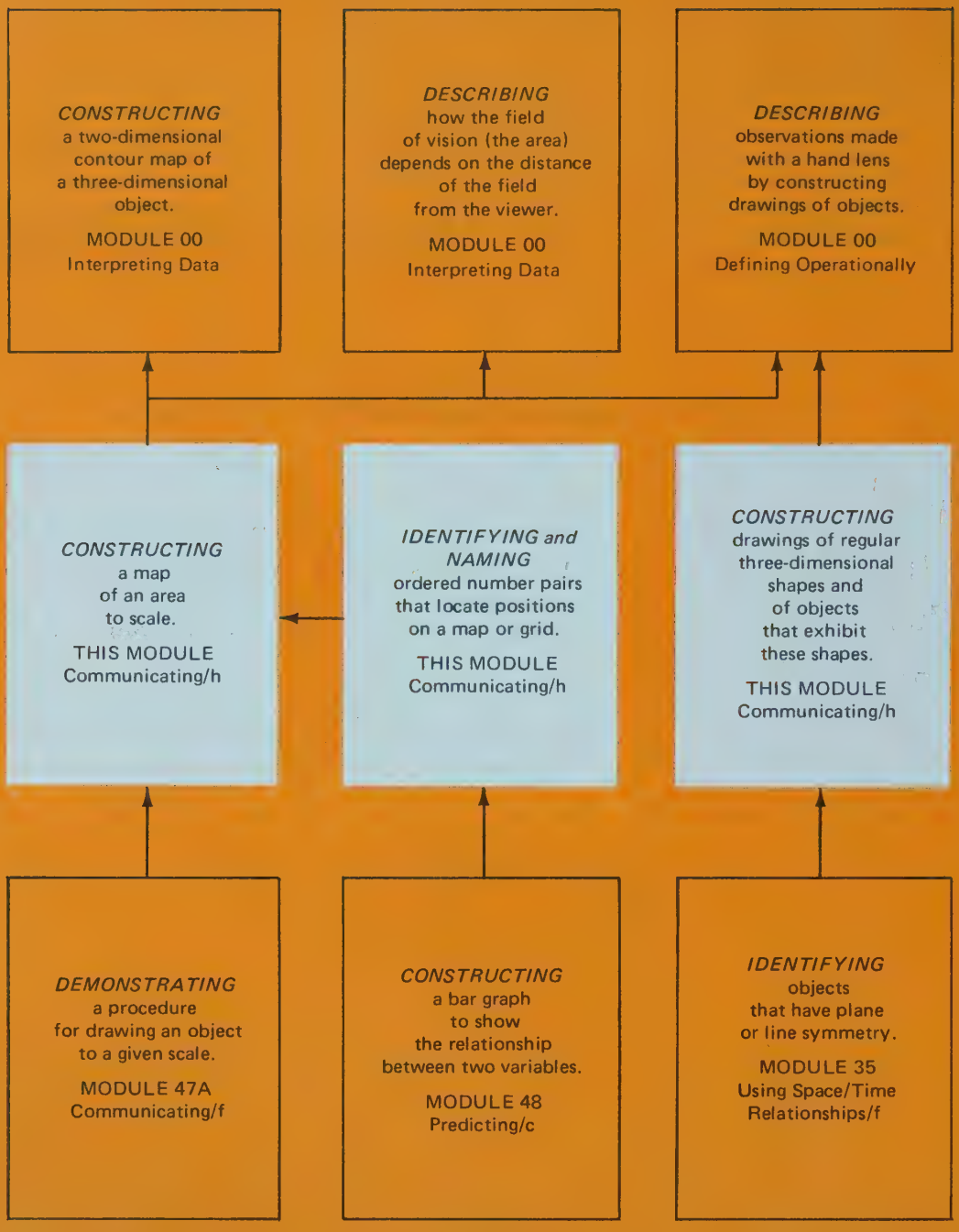
SEQUENCE


CONSTRUCTING a two-dimensional contour map of a three-dimensional object.
MODULE 00 Interpreting Data
DESCRIBING how the field of vision (the area) depends on the distance of the field from the viewer.
MODULE 00 Interpreting Data
DESCRIBING observations made with a hand lens by constructing drawings of objects.
MODULE 00 Defining Operationally
CONSTRUCTING a map of an area to scale.
THIS MODULE Communicating/h
IDENTIFYING and NAMING ordered number pairs that locate positions on a map or grid.
THIS MODULE Communicating/h
CONSTRUCTING drawings of regular three-dimensional shapes and of objects that exhibit these shapes.
THIS MODULE Communicating/h
DEMONSTRATING a procedure for drawing an object to a given scale.
MODULE 47A Communicating/f
CONSTRUCTING a bar graph to show the relationship between two variables.
MODULE 48 Predicting/c
IDENTIFYING objects that have plane or line symmetry.
MODULE 35 Using Space/Time Relationships/f

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

Thus far in the *Communicating* process, the children have developed the ability to describe what they have observed, in words and sometimes in graphs. In this module they read and construct simple maps, such as a map of the room; locate points by using a coordinate system of ordered number pairs; and construct drawings of prisms, pyramids, cylinders, and cones.

A map or a drawing should be accurate enough to fulfill its purpose. An architect must indicate precise measurements on building blueprints because, for example, the parts of a building must fit together tightly to keep out wind, rain, and cold. On the other hand, if you draw a map for friends to show them how to get from their house to yours, you can be quite inaccurate about distances, as long as directions, intersections, and landmarks are shown in the proper relationship to one another. In presenting this module, however, you should encourage the most precise representation of which your children are capable, since the making of a precise representation requires the careful attention to detail that is necessary in scientific work.

To describe precisely the location of points, lines, planes, or objects, a reference system is essential. One of those most widely used is the Cartesian, or rectangular, coordinate system. A brief review of the terminology of Cartesian coordinates follows here for your convenience, but you will not want or need to use all of these terms with the children.

As Figure 1 shows, there are two axes at right angles to each other; these axes are usually represented as horizontal and vertical. The horizontal axis is usually called the *x-axis* and the vertical axis, the *y-axis*. They meet at a point called the *origin*. Any convenient scale can be marked on the axes, starting with 0 at the origin. An axis is usually a number line, and it is customary for the axes to intersect at 0 on each number line. Similarly, it is customary for the positive ends of the number lines to be up (on the *y*-axis) and to the right (on the *x*-axis), but this is not essential.

The position of a particular point can be determined by drawing one line through the point parallel to the *y*-axis and another line, parallel to the *x*-axis. The line parallel to the *y*-axis meets the *x*-axis at a number called the *x-coordinate* of the point. Similarly, the line parallel to the *x*-axis meets the *y*-axis at a number called the *y-coordinate* of the point. The two numbers together, then, are called the *coordinates* of the point; they are written in parentheses as *(x, y)*, with the *x*-coordinate always written first. (See Figures 1 and 2.) Because the order in which the numbers are written is significant, the coordinates of a point are often called an *ordered pair*.

Coordinates are negative numbers when lines drawn through the point intersect the axes on the negative side of both number lines. (See Figure 2.)

In *Three-Dimensional Shapes, Using Space/Time Relationships d, Module 12,* and in *Shadows, Using Space/Time Relationships e, Module 29,* the children learned to recognize the two-dimensional shapes that are components of three-dimensional shapes. *Activity 5* of this

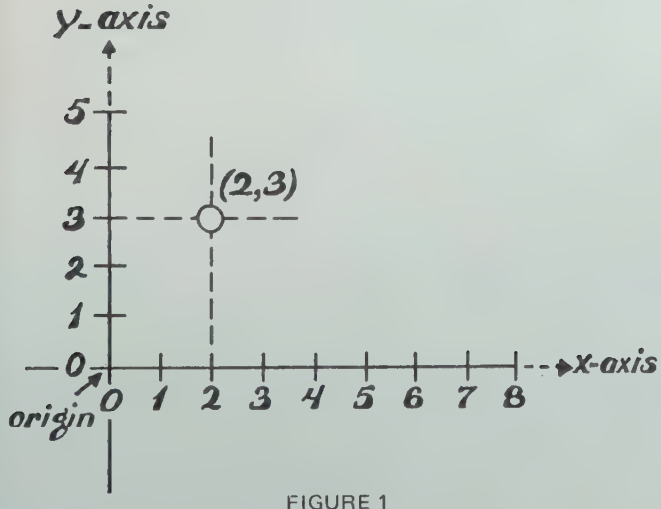

FIGURE 1

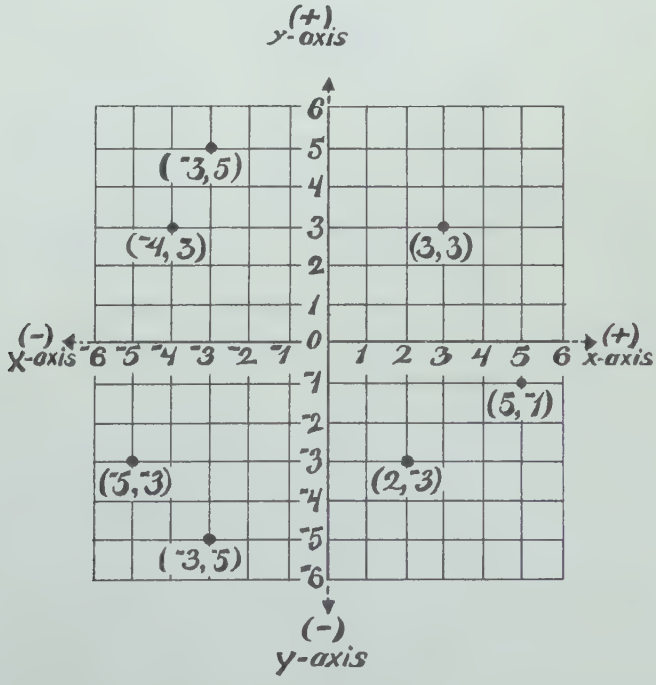

FIGURE 2

module extends the children's idea of space by introducing them to a consideration of the lines or curves that are the boundaries of three-dimensional figures. Using an auto-instructional booklet, the children first follow a cartoon character in the drawing of two-dimensional representations of three-dimensional shapes. The children then learn to view their representations as solid shapes, and to distinguish which lines are hidden and which lines are visible. They draw such objects as soda cans and ice cream cones that incorporate the three-dimensional shapes.

The representations of three-dimensional shapes that the children draw are maps of the three-dimensional shapes. When the children use coordinates to plot the corners of three-dimensional shapes on graph paper (Optional *Activity 6*), the children are required to combine several developing skills.

Some children may need help with linear metric measurement; others may need to review the number line and negative numbers.

Many of the activities in this module can be coordinated with social studies or art programs. Seek opportunities to do this.

Vocabulary

map	ordered number pair
code	rectangular prism
axis	square-base pyramid
x-axis	cone
y-axis	cylinder
intersect	key
coordinates	

INSTRUCTIONAL PROCEDURE

Introduction

Invite the children to work on either or both of the following projects. Most children probably will not have the time required for both activities unless they wish to work at home. If possible, coordinate these projects with the social studies program.

Ask the children to draw a map, at least roughly to scale, of the path they follow in going from home to school. For some children, especially for those who come to school by bus, this may be too complex. Suggest that these children choose other routes to map. In this context, drawing to scale means drawing so that Distance *A*, twice as long as Distance *B*, is represented by a line about twice as long as that for Distance *B*.

Give each child, or pair of children, a map of your state. Ask the children if they know how to use the scales of letters and numerals that they see along the edges. Help them locate a city. Then let them practice using these maps by giving them the two lists described in *Materials*. Using the list of letter-and-numeral coordinates, the children must identify the names of the corresponding cities or other major features; using the list of cities, the children must identify the corresponding letter-and-numeral coordinates.

Tell the children that in this module they will learn to represent position and shape by making scale drawings, by using coordinate systems like those used by scientists, and by making sketches of three-dimensional shapes. You may also want to tell them that they will learn to play a game called *Secret Signals* (see *Generalizing Experiences*).

Materials

Drawing paper, 1 sheet for each child
Pencils, 1 for each child
Maps of your state, 1 for each child
(Note: Some state agencies and gasoline companies will supply these free upon request.)
Lists, 2 for each child, one of letter-and-numeral coordinates of cities or other major features on the state map, and one of the names of cities on the state map

Activity 1

Tell the children that you want them to help you make a map of the room, and that if they all make these maps, they can take them home to show their parents. Then, when parents or brothers or sisters visit school, they will know where the children sit and where books, papers, and other things are located.

Give metersticks to several groups of children and ask them to measure the length and width of the room. (See Figure 3.) When they have agreed on the measurements to the nearest tenth of a meter, write descriptive statements such as the following on the board.

The room is 10.3 meters long on the window side.
The room is 8.6 meters wide across the front.

After discussion about a convenient scale to use, ask two children to come to the chalkboard and make the drawing as carefully as they can. If the chalkboard space is large enough, they can choose a scale of 1 meter to 1 decimeter, or, even better, 1 meter to 2 decimeters. If you think the children need a review of the concept of scale, remind them how they measured the scale of dinosaur pictures (*Scale Drawings, Communicating f, Module 47*).

Distribute metric rulers to the children at their desks. As the two children are making the drawing on the chalkboard, discuss with the other children a scale that they might use on paper at their desks. A good choice may be 1 meter to 1 centimeter. If the room is shaped irregularly, the children will need extra help.

When the children make their scale drawings, you may want to have them round off the room measurements to the nearest meter. Your decision should be based on their competency in using decimals.

Have the children keep their maps of the room for the next activity. Also retain the map on the chalkboard.

Materials

Metersticks, 10 (*Module 48*)
Metric rulers, 30 (*Module 47*)
Drawing paper, 1 sheet for each child
Pencils, 1 for each child

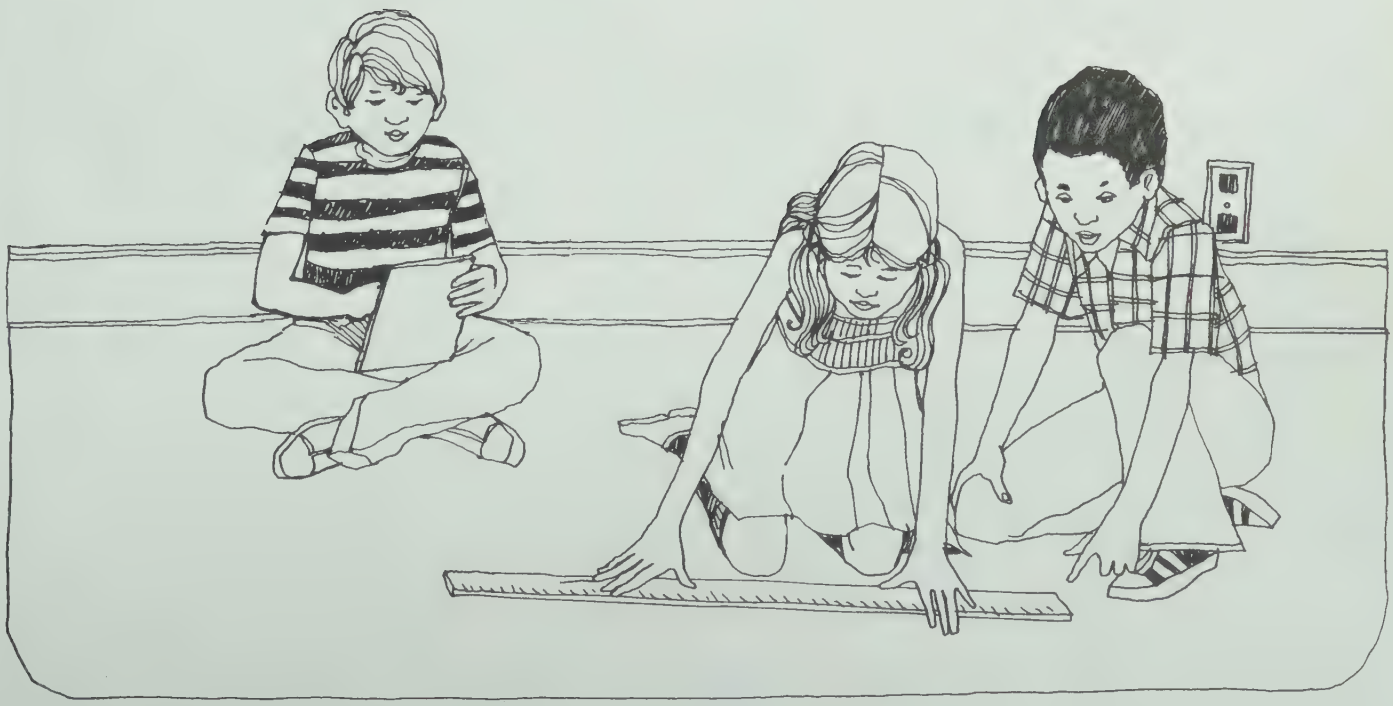

FIGURE 3

Activity 2

Let those children who can and who want to, work independently during this activity. Or, pair the children so that one child can assist another as they work together. If two children make their measurements together, they are apt to be more accurate than if they work alone. Although great accuracy is not the ultimate goal of this module, always encourage careful work.

Ask the children to suggest objects of furniture or other details in the room that they would like to show on the maps that they made in the previous activity. They may want to show the location of your desk, the windows and doors, display tables, or the sink. Agree on one object to locate first. Suppose, for example, it is the object marked *A* in Figure 4.

Assign two pairs of children to map-making at the chalkboard. Have the first pair measure the distance along the floor from Object *A* to one wall of the room (*AB* in Figure 4), while the second pair measures the distance from Object *A* to the adjacent wall of the room (*AC* in Figure 4). Tell the children to round off the distances to the nearest meter or tenth of a meter, whichever is appropriate for your children.

To transfer these floor measurements to the map on the board, tell the children to start at the lower left-hand corner (*O* in Figure 5) of the map and to measure the number of decimeters along the lines representing the two walls. The number of decimeters will correspond to the number of meters if the scale of 1 meter to 1 decimeter is used. If the room has square corners, the children will readily see that *OC* represents the measured distance *AB*, and that *OB* represents the measured distance *AC*. When they have located points *C* and *B* on the map on the board, have one child draw a line straight up from *C* and have another child draw a line straight across from *B*. These lines will meet at *A*, which then represents the position of Object *A*. The shape of the object may be drawn around point *A*. When the object is located, ask a child to erase the lines from *C* and *B*.

Have all the children locate Object *A* on their individual maps according to the scale they chose previously. Follow the same procedure to locate other objects.

Repeat this activity on other days with other pairs of children and different furniture arrangements. It is important to involve as many children as possible in the actual measuring in the room and the plotting on the board.

Materials

Metersticks, 10 (*Module 48*)
Metric rulers, 30 (*Module 47*)
Individual classroom maps, from *Activity 1*
Pencils, 1 for each child

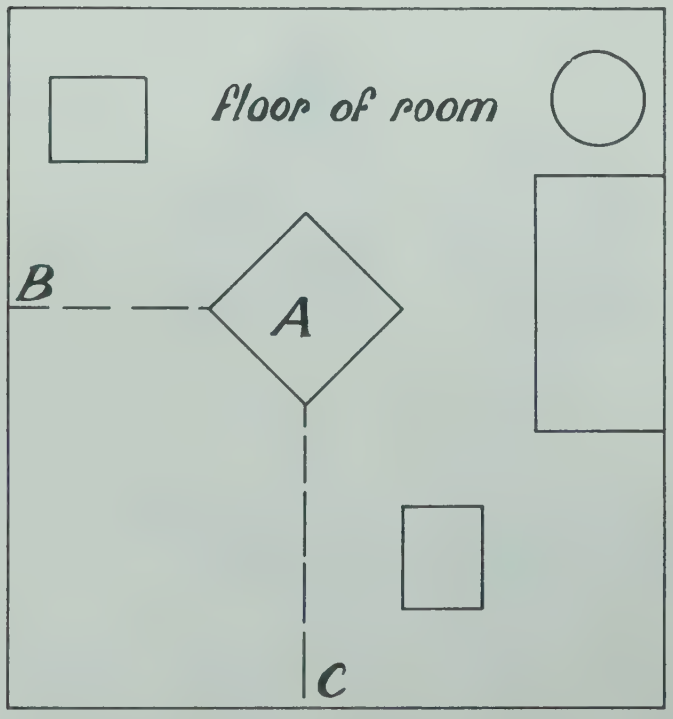

FIGURE 4

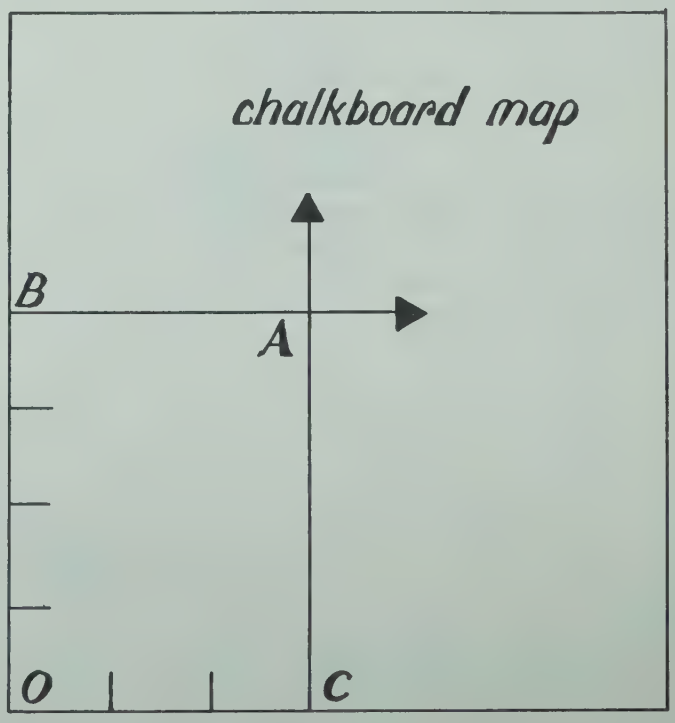

FIGURE 5

Activity 3

With the children's assistance, draw on the chalkboard, or on a large sheet of paper that you fasten to the board, a map of the present seating arrangement in the room. The map might be something like that in Figure 6, but without the letters and numerals.

Ask several children to identify their seats on the map. Point to a seat and ask who is sitting there. Then ask the children to suggest ways in which the seats could be coded so that any child could identify any seat without pointing to it. One way is shown in Figure 6. Each seat is identified by both a letter and a numeral. For example, the seat about which a circle has been drawn is seat 4D. It is not necessary to use this particular coding scheme. Try out any of the children's suggestions that seem promising.

The advantage of the letter-numeral system is that it requires two symbols to identify a position. Most other coding systems that are short and easy to use will also be based on two components. Whatever schemes are devised, be sure the children use them repeatedly to identify different places. The practice will provide an excellent introduction to coordinate systems.

Before concluding this activity, encourage each child to develop his or her own map showing a seating arrangement. Some children may be satisfied to copy the map already displayed. Mention that sometimes the seating arrangement is different for certain activities. Some children may decide to map those arrangements. Invite the children to propose seating arrangements that they would like and which you may not have considered.

Materials

Paper, 1 large sheet (optional)
Marking pen, 1 (optional)
Drawing paper, 1 sheet for each child
Pencils, 1 for each child
Metric rulers, 30 (*Module 47*)

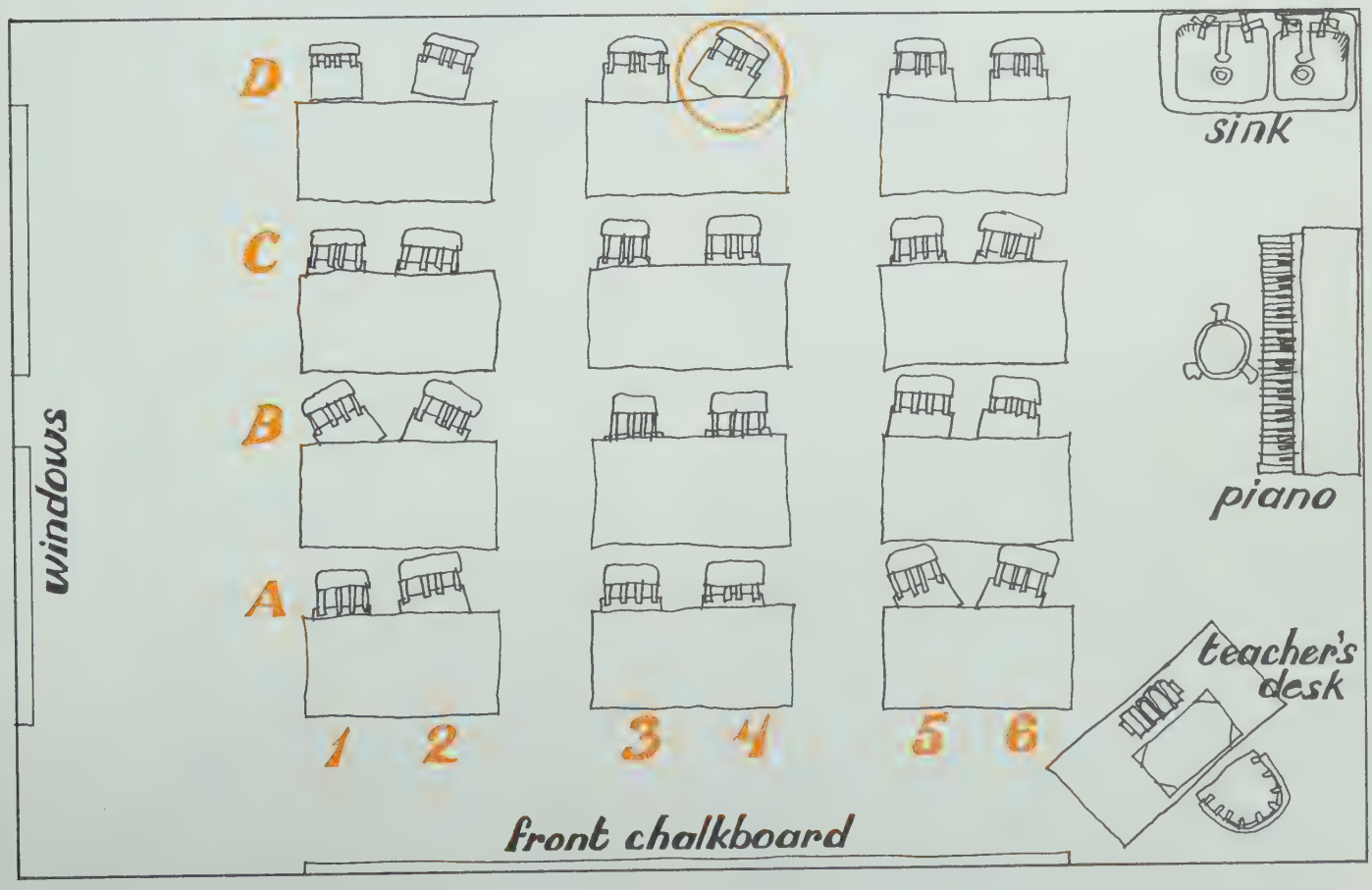

FIGURE 6

Activity 4

Use a transparent grid at the overhead projector or make a chalkboard grid. The grid should be large enough for the children to see, and should have at least ten lines both vertically and horizontally. Label the *x*-axis and *y*-axis as such, but do not number either axis yet.

Put a point at the intersection of two lines—perhaps where the line crossing the *x*-axis at *2* intersects the line crossing the *y*-axis at *4*. Now ask the children to describe the exact location of this point. If they start to count, ask them if numbering the grid would help. They will probably agree that the grid should be numbered as in Figure 7.

Ask for a volunteer to name two numbers to describe the exact location of the point. Tell the children to read the number on the *x*-axis first and the one on the *y*-axis second. Suggest that one way to remember this order is that *x* comes before *y* in the alphabet. When someone has successfully answered (*2, 4*), have another child put a point on the graph at the intersection of any other two lines. Then ask a different child to describe the location by stating the number pair. Give several children an opportunity to participate.

Then show the children the notation that is used to write an ordered number pair: the open parenthesis, the *x* numeral, a comma, the *y* numeral, and the close parenthesis.

Ask a volunteer to write any ordered number pair on the chalkboard. Suppose, for example, that the child writes (*7, 6*). Choose another child to mark that location on the grid. He should trace along the *x*-axis to *7* and then up that line to its intersection with the line crossing the *y*-axis at *6*. Then he should mark the intersection of these two lines with a large dot.

Repeat this activity several times and include different children each time.

Review with the children the positions of negative numerals on a number line. Then extend the axes on the grid to include the negative whole numbers from ⁻*1* to ⁻*10*. Show the children the location of several points using negative coordinates, as shown in Figure 8. Develop the concept in the same way that was previously suggested for positive coordinates, again including as many children as possible. Continue this activity as long as interest holds.

Materials

Transparency, 1, duplication of *Graph Paper* (*Module 48*)
Overhead projector, 1
Transparency marker, 1

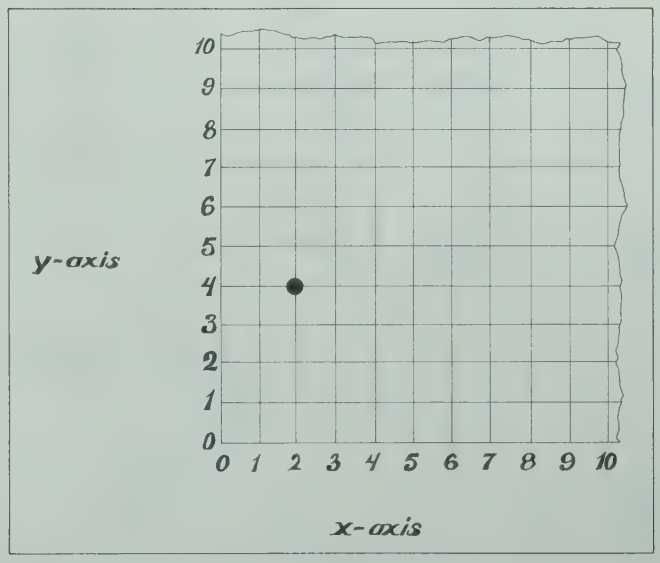

FIGURE 7

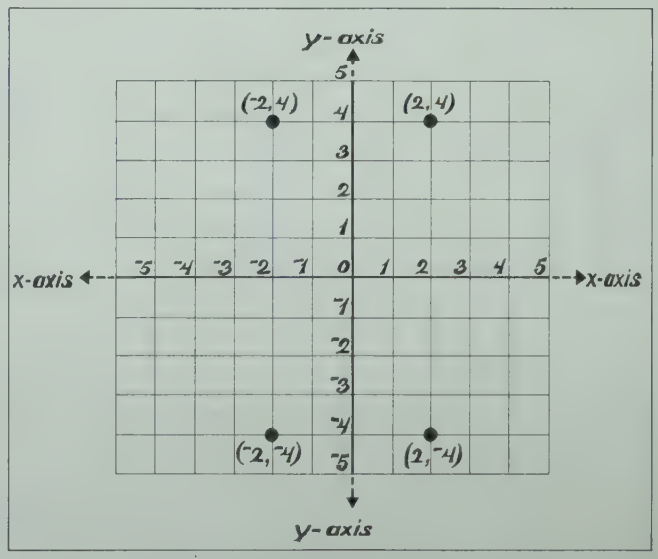

FIGURE 8

Activity 5

Place on a table the solid and wire shapes described in *Materials,* several copies of the auto-instructional booklet *Paul Pencil's Shapes,* a pencil, and a supply of drawing paper. Ask the children to work alone as they follow the instructions in the booklet and to complete one page before going on to the next. Tell them to do all work on separate sheets of paper and to number each sheet of paper according to the page being worked on in the booklet. Have the children bring you their finished work to be checked.

Materials

Solid shapes, 6, one of each shape: a cube, a cone, a cylinder, a square-base pyramid, a sphere, and a rectangular prism (*Module 57*)
Wire shapes, 6, one of each shape: a cube, a cone, a cylinder, a square-base pyramid, a sphere, and a rectangular prism (*Module 57*)
Paul Pencil's Shapes, 5 booklets (*Module 57*)
Pencils, 1 for each child
Drawing paper, several sheets for each child

Activity 6 (Optional)

This activity gives the children practice both in using coordinates and in constructing two-dimensional representations of three-dimensional shapes.

Give each child three sheets of graph paper and a pencil. Have several metersticks available. Ask the children to construct *x*- and *y*-axes on one of the grids, and to label the axes and the number lines.

Ask the children to plot the following points:

$(^-3, 1), (^-1, ^-3), (^-5, ^-3)$ (2, 1), (4, 5), (6, 1).

When they have done this, suggest that they connect the points as Paul Pencil might have done. There is more than one way in which the points might be connected. When the children have finished their drawings, discuss the possibilities, and help them to identify shapes among the solid and dotted lines in their drawings. Have the children write the name of the three-dimensional shape, triangular prism, on the figure.

Now give the children the two sets of coordinates that follow; suggest that they again try to connect the points as Paul Pencil might have done.

$(^-3, ^-4), (4, ^-5), (^-2, 7), (^-3, ^-6), (5, ^-8), (4, ^-7), (^-2, ^-5), (5, 6)$
(1, 2), (2, 8), $(^-4, 2), (^-4, 7), (^-3, 8)$, (2, 3), $(^-3, 3)$, (1, 7)

Ask what shape each set of points represents. (First set: rectangular prism; second set: cube.)

If interest continues and you feel additional practice is needed, ask for volunteers to make "puzzles" for other children to solve. Have those who volunteer draw simple pictures on graph paper; the pictures might be two-dimensional shapes, letters of the alphabet, or other diagrams, as well as representations of three-dimensional shapes. Have the children mark the essential points of each diagram, and list the coordinates for each point. You can then give the lists of coordinates to those children who want or need practice in using coordinates.

Materials

Graph Paper, 1 spirit master (*Module 57*)
Pencils, 1 for each child

Generalizing Experiences

1. Give each child a metric ruler, a pencil, and a copy of *First and Main*. Point out to the children the map of a street intersection (Map *A*) and tell them to make a larger map of the intersection in the larger rectangle (Map *B*). They should do this by first noting that the larger rectangle is twice as long and twice as wide as the smaller rectangle. Each distance on Map *A* must therefore be doubled on Map *B*.

2. Have the children choose partners to play *Secret Signals*, a game similar to "Battleship," which is popular with children. *Secret Signals* is played on a grid similar to that shown in Figure 9. Positions or points on the grid are identified with ordered number pairs. Two children play the game.

Give each child two sheets of graph paper and a pencil. Have the children draw *x*- and *y*-axes on one of their sheets of graph paper, such that the axes intersect near the center of the grid. Have the children label the positive and negative number lines.

To prepare to play the game, each child draws on his or her grid a design comprising the child's secret signals. The design consists of four line segments called Signal 2, Signal 3, Signal 4, and Signal 5. Signal 2 is a straight line between two points on the grid, Signal 3 is a straight line through 3 points, and so on. The signals must form a connecting chain, and may be drawn only on lines or

diagonals of the grid squares. (See Figure 9.) The chain of signals may form a letter, a shape, or an irregular path—perhaps to buried treasure. Suggest that the children think of their secret signals as a code to be "cracked." The children must take care that their opponents do not see their secret signals.

To play the game, the children take turns calling out ordered number pairs, each pair indicating a point on the grid. As a number pair is called, the other child has to say whether or not one of the points of a signal in his or her code has received a "crack," and if so, which signal. For example, if one child is playing with the array shown in Figure 9, and the second child calls, "(1, 1)," the first child would say, "No crack." If, on the other hand, the second child calls, "(⁻1, 2)," the first child would say, "You made a crack in Signal 2 and Signal 4." The game is won by the child who cracks all of the points of the other child's secret signals (Figure 9 has a total of 11 such points.).

The blank sheet of graph paper that each child has is used to record the number pairs that he or she calls, and to note which calls cracked one or more of the opponent's signals.

3. Give each child a sheet of graph paper and a pencil. Tell the children to construct *x*- and *y*-axes so that they can locate negative and positive coordinates. Ask the children to plot a point for each of the following number pairs as you name it, and to connect each point with a line segment in order as it is plotted: (3, 6), (3, ⁻2), (1, ⁻4), (1, 4), (⁻4, 4), (⁻2, 6), (⁻2, ⁻2), and (⁻4, ⁻4). Then suggest that the children join additional points to make a two-dimensional representation of a box, or rectangular prism. In Figure 10, heavy line segments join the points in the order that they are plotted; dotted lines show the segments needed to complete the figure. Ask the children how they might correct the drawing to make it look like a real box, or solid rectangular prism. (Some of the solid lines should be dotted and some of the dotted lines should be solid.)

Materials

Graph Paper, 1 spirit master (*Module 57*)
Pencils, 1 for each child
Metric rulers, 30 (*Module 47*)
First and Main, 1 spirit master (*Module 57*)

SECRET SIGNALS

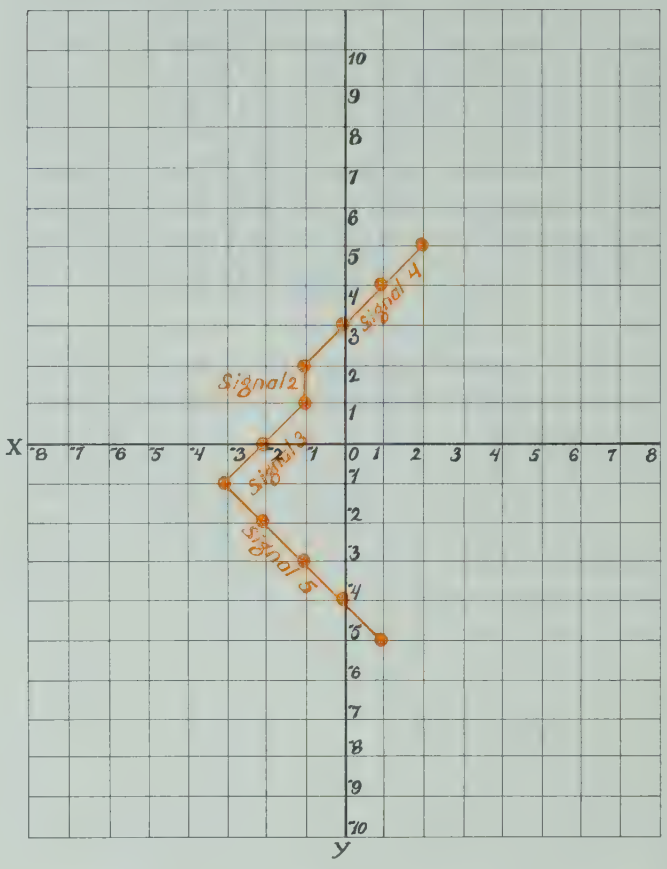

FIGURE 9

CONSTRUCTING A RECTANGULAR PRISM

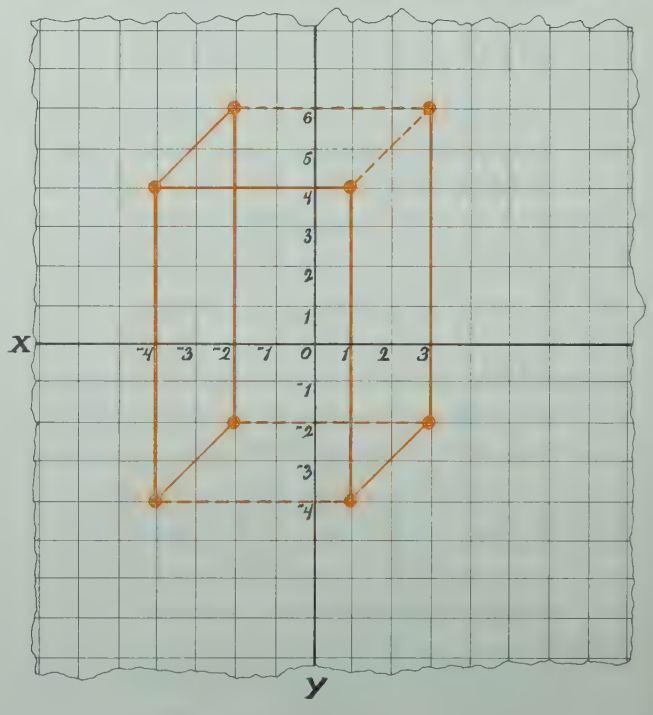

FIGURE 10

APPRAISAL

On the state map that you used in the *Introduction*, locate a campground, a park, or other special area that is identified by a symbol shown in the map key. Give the children the letter-and-numeral coordinates and describe the symbol in general terms. Then ask the children to find the symbol and to tell you what it stands for.

Give each child a pencil and a sheet of graph paper on which you have drawn Figure 11 in one corner. Ask the children to construct the figure by using a scale two times as large.

Give each child a pencil and a copy of *Make a Word*. Have the children follow the instructions on the sheet and show it to you when they have finished.

Materials

Maps of your state, 30
Graph Paper, 1 spirit master (*Module 57*)
Pencils, 1 for each child
Make a Word, 1 spirit master (*Module 57*)

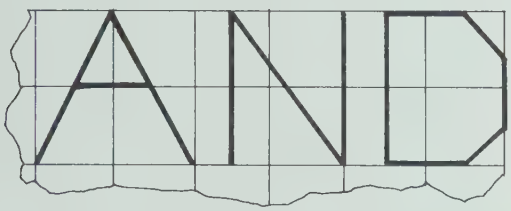

FIGURE 11

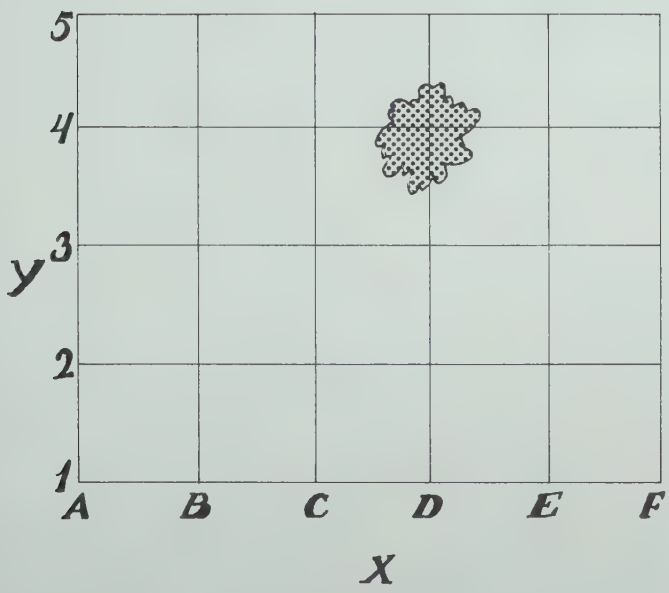

FIGURE 12

COMPETENCY MEASURE

For *Tasks 1* and *2*, give the child a pencil and a copy of Figure 12.

TASK 1 (Objective 1): Say to the child, This is a map of Dick's garden. Dick planted a tree at (B, 3). Put an X where Dick planted the tree. The child should put an *X* at (B, 3).

TASK 2 (Objective 1): Point to the outline of the tree on the map and say, Dick already had a tree in his garden, here. What is the position of the tree? The child should say, "(D, 4)" or "(4, D)."

TASK 3 (Objective 2): Give the child a metric ruler, a pencil, the picture card of a city map, and a sheet of paper. Say, Construct the city map to scale on this sheet of paper so that each of the squares is 1 centimeter on a side. The child should construct the map correctly.

For *Tasks 4* and *5*, show the child the picture card of the names of school subjects positioned on a graph.

TASK 4 (Objective 3): Ask, What coordinates (or number pair) mark the last letter of the word *Science*? The child should say, "(7, 4)."

TASK 5 (Objective 4): Write the coordinates (7, 5) on a piece of paper and show the paper to the child. Ask, What letter is at this position? The child should say, "H."

TASK 6 (Objective 5): Give the child a pencil and a sheet of paper. Show the child a square-base pyramid, and say, Draw a picture of a square-base pyramid like this one. The child's drawing should be similar to one of those shown in Figure 13.

Materials

Pencils, 1 for each child
Metric rulers, 1 for each child (*Module 47*)
City Map, 1 picture card (*Module 57*)
Drawing paper, 2 sheets for each child
What's Your Subject?, 1 picture card (*Module 57*)
on a graph (*Module 57*)
Square-base pyramid, 1, solid or wire (*Module 57*)

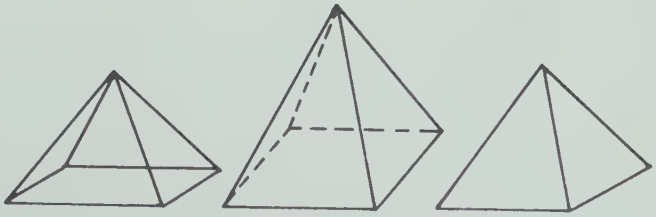

FIGURE 13

ABCDEFGH 076543
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SCIENCE...

A PROCESS APPROACH II

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SCIENCE... A PROCESS APPROACH II

MODULE

58

Inferring/e

Liquids and Tissues

OBJECTIVES

At the end of this module the child should be able to

1. *DESCRIBE* observations of the effect of a liquid on plant or animal material.
2. *DISTINGUISH* between observations of and inferences about the effect of a liquid on plant or animal material.
3. *CONSTRUCT* an inference to explain the effect of a liquid on plant or animal material.

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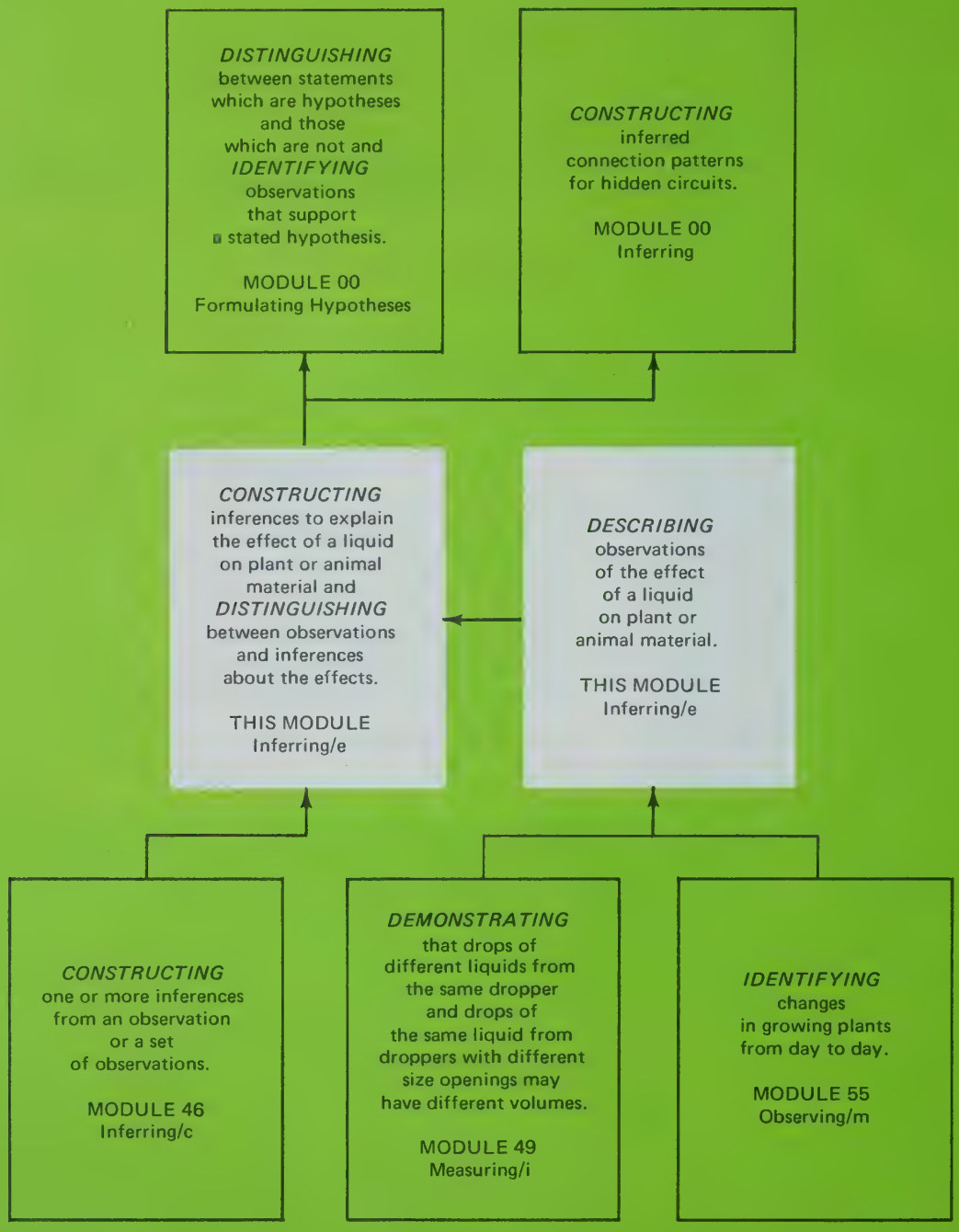
AAAS

SEQUENCE



Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

In earlier modules the children made inferences from their observations of familiar situations. Here, they will make inferences from observations of less familiar phenomena, and they will also test these inferences. As before, the children will be asked to give their reasons for the inferences they make.

Some children make better inferences than others because they make more observations, keep their observations more clearly in mind, or have a richer store of prior knowledge to draw on. This difference in the children's ability to infer should be an advantage to all, as the children will have an opportunity to compare a variety of inferences.

Because the children are asked to report their investigations both orally and in writing, this module can be used to teach skills in oral and written language. To give each child maximum practice in recording observations and inferences, it is suggested that the children each keep their own records. However, it may not be possible for some children to do so, and in those cases you may want to designate one pupil in each group to be the recorder. If this is done, it is suggested that you meet with each child individually to discuss his or her observations and inferences.

This module is designed to enable the children to work with minimum teacher direction, and in this sense it is auto-instructional. All activities are best carried on by groups of two or three children. Each activity may be conducted with all groups working simultaneously in the room, or each pair or group may work on a time schedule independent of all other groups. Some teachers prefer to tape-record instructions for those students who are unable to read the instructions but who can do the laboratory work. For each activity, all the materials needed should be made available with the instructions.

In a module such as this, in which much of the learning takes place as children work in pairs independently of the teacher, the *Appraisal* takes on added importance. Be sure to administer the *Appraisal.*

Vocabulary

effect
liquid
alcohol
solution
tissue

INSTRUCTIONAL PROCEDURE

Introduction

Ask the children to gather around a table on which you have placed several containers, each with about 70 milliliters of citric acid solution. As the children watch, crush about one-fourth of an egg shell and add it to each container. Ask the children to watch carefully so they can report what they observe. After a few seconds, bubbles will appear and the egg-shell pieces will float to the surface. Some pieces will lose bubbles and sink. More bubbles will form and the pieces will again rise to the surface. After a few minutes, have some of the children stir the materials in the container nearest them. You may want to list the children's observations on the chalkboard. If any children state inferences, be sure that they are identified as such. Encourage the children to make inferences about their observations.

Suggest to the children that they work in groups of two or three to investigate the effect of some kinds of liquids on plant and animal tissues. Explain that a tissue is a section of material that is or was once part of a living plant or animal.

Tell the children that they are to follow the written instructions on the sheets that you will give them, to collect materials from the place you designate, and to ask advice or help only if they need it.

Materials

Containers, 8, 120-ml (*Module 58*)
Citric acid crystals, 1 container (*Module 58*)
(Note: Prepare citric acid solution by measuring a volume of 80 milliliters of citric acid crystals with a graduated cylinder and dissolving the crystals in 400 milliliters of water.)
Graduated cylinder, 1, 50-ml (*Module 49*)
Egg shells, 3 or 4
Rods, 3, for stirring (*Module 56*)

Activity 1

Give each pupil a copy of *Tissues and Liquids—Activity 1.* Have the children prepare sheets for recording their observations and inferences similar to the one shown in Figure 1. Review with the children the location of the materials, the instructions, their group organization, and any general hints you think are needed to initiate the activity. Some pupils may require help in slicing the potatoes.

As a group completes the activity, discuss their results with them or review their individual record sheets. When they are ready, let them proceed with *Activity 2.*

Materials

Tissues and Liquids—Activity 1, 2 spirit masters (*Module 58*)
Writing paper, 1 sheet for each child
Pencils, 1 for each child
Graduated cylinders, 6, 50-ml (*Module 49*)
Containers, 15, 250-ml, plastic (*Module 49*)
Containers, 30, 120-ml, plastic (*Module 58*)
Salt, 1 container (*Module 58*)
(Note: Label this *Material 1.*)
Masking tape, 1 roll
Spoons, 12, plastic (*Module 58*)
Potatoes, 4 or 5, peeled
Knives, 5, plastic, with serrated edges
Hand lenses, 15 (*Module 52*)

My observation	My inferences
Other things I might want to think about and work on	

FIGURE 1

Activity 2

The teaching procedures for this activity are the same as those for *Activity 1.* When a group is ready to start the investigation, give each child a copy of *Tissues and Liquids—Activity 2* and have each pupil prepare a sheet for recording observations and inferences. Before the children begin this activity, test the number of leaves needed to produce a deep emerald green color in Step 4. Inform the children if the instructions need to be altered.

Materials

Tissues and Liquids—Activity 2, 3 spirit masters (*Module 58*)
Writing paper, 1 sheet
Pencils, 1 for each child
Graduated cylinders, 6, 50-ml (*Module 49*)
Containers, 30, 120-ml, plastic (*Module 58*)
Alcohol, 1 container, denatured (*Module 58*)
Masking tape, 1 roll
Green leaves, approximately 50, such as spinach or grass
Rocks, approximately 10, flat, for crushing leaves
Rods, 3, for stirring (*Module 56*)
Spoons, 12, plastic (*Module 58*)
Paper towels
Droppers, 30 (*Module 49*)
Scissors, 5

Activity 3

The teaching procedures for this activity are the same as those for *Activity 1*. When a group is ready to start the investigation, give each child a copy of *Tissues and Liquids—Activity 3* and have each child prepare a sheet for recording observations and inferences.

Materials

Tissues and Liquids—Activity 3, 2 spirit masters (*Module 58*)
Writing paper, 1 sheet for each child
Pencils, 1 for each child
Liver, 30 to 40 pieces, each about 2-cm, beef or pork
Wax paper, 30 sheets
Rocks, approximately 10, flat, for mashing liver
Hydrogen peroxide, 250 ml, 3% solution
(Note: Label this *Solution D*.)
Hand lenses, 15 (*Module 52*)
Droppers, 30 (*Module 49*)
Spoons, 12, plastic (*Module 58*)

Activity 4 (Optional)

Set out a variety of plant and animal materials for the pupils to test, and several liquids with which to treat the materials. *CAUTION: All liquids should be safe and labeled. If you want to ask the children to bring liquids from home, be sure to check that the material a child brings is safe and appropriate to use. Warn the children never to taste any substance without your approval.*

Ask the pupils to suggest questions and topics they might examine. If necessary, suggest one or more of the questions listed below:

1. Will solutions other than Solution A *(see Materials)* make potatoes soften?
2. Will Solution A make all plant and animal tissue soften?
3. Will all animal tissue give off bubbles when Solution D *(see Materials)* is added?
4. Will plant tissue give off bubbles when Solution D is added?
5. Are there other solutions that make plant and animal tissue bubble?
6. Does the size and shape of the tissue make a difference as to how fast bubbles are given off when Solution D is added?
7. Does the size and shape of the tissue make a difference as to how quickly it will soften in Solution A?

Allow the pupils to try as many of these investigations as they may like. Encourage them to record observations and to make inferences. Some may continue to work on these investigations much longer than others.

Materials

Materials that were used to help make observations in *Activities 1, 2 and 3*, for example spoons, scissors, rocks, hand lenses
Plant and animal tissues, an assortment, such as cooked meat, raw meat, radishes, carrots, turnips, cooked egg, raw egg, plant stems, leaves, flower petals
Liquids, an assortment, such as vinegar, cooking oil, soap solution, lemon juice, diluted bleach, mouthwash, salt water (Solution A prepared by the children during *Activity 1*), and hydrogen peroxide (Solution D used in Activity 3).
(Note: Label the contents of all containers clearly. If children bring liquids from home, check to make sure they are safe to use.)

Generalizing Experiences

Discuss with the children the idea that it is common practice to use liquids on plant and animal materials that are eaten as food. Ask if they can think of any examples. As the children present suggestions, be sure to differentiate between those liquids that are added only for taste, such as vanilla flavoring, steak sauce, and salad dressings, and those liquids that actually effect a change in the plant or animal material to which they are added, such as the wines, vinegar, oil, and lemon juice used to marinate meats and vegetables; the vinegar, salt, and sugar solutions used in pickling and canning; and the water used to soak prunes.

If the children seem interested, you may suggest that they decorate a bulletin board with pictures of a food both before and after being treated, of the liquid used, and of the treatment process. A group of children might also treat different plant and animal food materials with various liquids. Be sure to give the group an opportunity to report to the other children their observations of the changes that occurred during their investigation.

Materials

Pictures for a bulletin board, for example a food before and after being treated with a liquid, the liquid used, and the treatment process (optional)

Assorted food materials and liquids with which to treat them (optional)

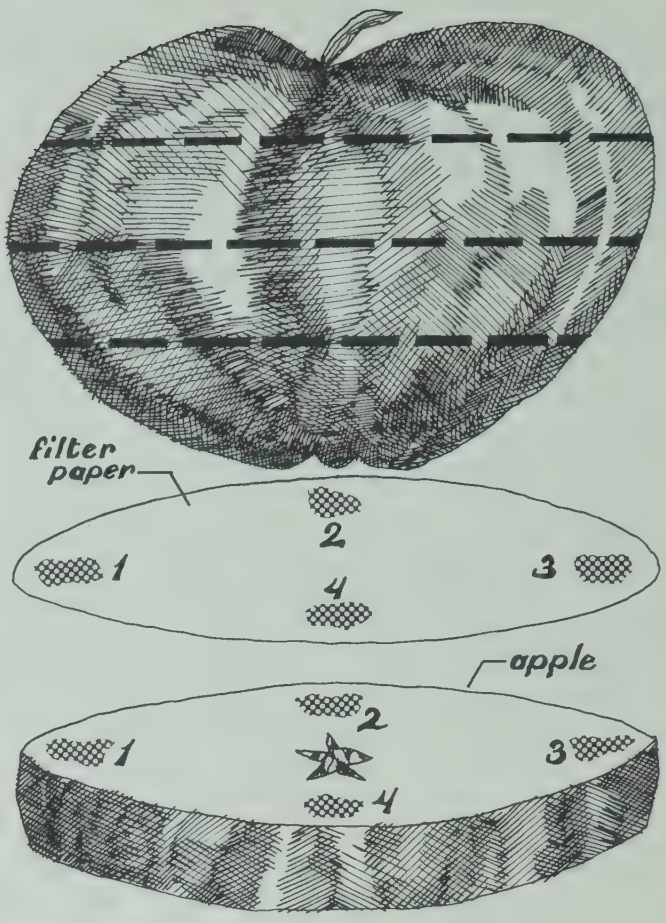

FIGURE 2

Sample Observations

1. Liquid 1 is blue-green in color.
2. Liquid 2 is blue in color.
3. Liquid 3 is red in color.
4. Liquid 4 is red in color.
5. Liquid 1 changed from blue-green to orange on the apple.
6. The edge of the spot of Liquid 1 changed from blue-green to orange on paper.
7. Liquid 2 did not change color on the apple.
8. Liquid 2 did not change color on the paper.
9. Liquid 3 changed from red to black on the apple.
10. Liquid 3 did not change color on the paper.
11. Liquid 4 did not change color on the apple.
12. Liquid 4 did not change color on the paper.
13. All liquids spread on the apple and the paper.
14. Liquids 1 and 3 first changed color at the edge of the drops.
15. Liquids 1, 2, 3, and 4 do not have an odor.
16. No bubbles formed when Liquids 1, 2, 3, and 4 were added.

Sample Inferences

1. Liquid 1 is not the same as Liquid 2. (Based on Observations 1, 2, 5, 7.)
2. Liquid 3 is not the same as Liquid 4. (Based on Observations 9, 11.)
3. Liquids 1, 2, 3, and 4 are different from each other. (Based on Observations 1-12.)
4. Something in the apple makes Liquid 3 change color. (Based on Observations 9, 10.)
5. The apple prevents Liquids 2 and 4 from changing color. (Based on Observations 7, 11.)
6. The paper prevents Liquids 2, 3, and 4 from changing color. (Based on Observations 8, 10, 12.)
7. Liquid 1 will change color when added to many things. (Based on Observations 5, 6.)
8. Liquids 1 and 3 will change colors only when added to fruits. (Based on Observations 9, 10.)
9. Apple juice makes some liquids change color. (Based on Observations 5, 9.)
10. Liquid 1 will change color if left on paper for several days. (Based on Observation 6.)
11. The paper and the apple are made of different materials. (Based on Observations 5, 6, 9, 10.)

FIGURE 3

APPRAISAL

Immediately before you begin the *Appraisal*, slice one or more apples or pears crosswise into sections approximately 1 centimeter thick (see Figure 2). Cut one section for every four children. Store the sections in a plastic bag to prevent discoloration.

Divide the children into groups of four. Place a sheet of newsprint on each desk to protect the top. Place one piece of filter paper and one slice of apple on the newsprint. Have the children number sections of the filter paper and of the piece of apple from 1 to 4 as shown in Figure 2. Show each group the bromothymol blue solution, refer to it as Liquid 1, and then place one small drop on both the apple slice and the filter paper adjacent to the numeral 1. Allow the children a brief time to observe. Repeat this procedure in turn for the remaining three solutions: blue food coloring, Liquid 2; Congo red solution, Liquid 3; and red food coloring, Liquid 4.

Have the children describe and discuss their observations. Ask them to construct inferences to explain their observations. Be sure the children distinguish between their observations and inferences. After a period of time, select two observations and two inferences from the lists shown in Figure 3 and write them on the chalkboard. Taking one statement at a time, have the children decide if it is an observation or an inference. Discuss each statement.

If time permits and the children are interested, discuss with them how they might test their inferences, and then provide them with the time and material to do so.

Materials

Apples or pears, 2
Knife, 1
Newsprint, 7 or 8 sheets
Filter paper, 10 sheets (*Module 58*)
Bromothymol blue solution, 1 container (*Module 58*)
Food coloring, 2 containers, one of each color: blue and red (*Module 49*)
Congo red solution, 1 container (*Module 58*)
Droppers, 30 (*Module 49*)

COMPETENCY MEASURE

TASK 1 (Objective 1): As the child watches, cut a slice of potato 1 centimeter thick. Place a sheet of newsprint on the child's desk, and on it place the potato slice and a piece of filter paper. Say, Watch what happens when I add these liquids, Liquid 5 and Liquid 6, to the potato and paper. Then, add one drop of iodine solution, Liquid 5, to both the potato slice and the filter paper. Repeat for the yellow food coloring, Liquid 6. Say, Describe one or two observations. The child should say that there was no color change on the paper, that Liquid 5 changed color on the potato, or any other statement that is a description of an observation.

TASK 2 (Objective 2): Say, I am going to read to you some statements I might make about what we have seen here. As I read each statement, tell me whether it is an observation or an inference.

1. The juice in the potato caused Liquid 5 to change color.
2. Liquid 6 did not change color on the potato or on the paper.
3. Liquid 6 had more yellow color material than Liquid 5.

Pause after each statement for the child's response. The child should identify statements 1 and 3 as inferences and statement 2 as an observation.

TASK 3 (Objective 3): What inference can you make to explain why Liquid 5 changed color on the potato and Liquid 6 did not? The child should say that Liquid 5 is different from Liquid 6, or any other statement that is an explanation of the observations.

Materials

Iodine solution, 1 container (*Module 58*)
(Note: Prepare dilute iodine solution by adding commercial iodine solution drop by drop to 10 milliliters of water until the new solution is the same color as the yellow food coloring. Label this iodine solution *Liquid 5*.)
Food coloring, yellow (*Module 58*)
(Note: Label this *Liquid 6*.)
Newsprint, 5 sheets
Filter paper, 1 package (*Module 58*)
Potato, 1
Knife, 1

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58 Inferring/e

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SCIENCE... A PROCESS APPROACH II

MODULE

59

Using Numbers/e

Metersticks, Money and Decimals

OBJECTIVES

At the end of this module the child should be able to

1. *DEMONSTRATE* how to write decimal notation for parts of a dollar.
2. *CONSTRUCT* points on a number line, using decimal notation for tenths and hundredths.
3. *DEMONSTRATE* how to use and write measurements to the nearest tenth of a unit using meters, decimeters, and centimeters.

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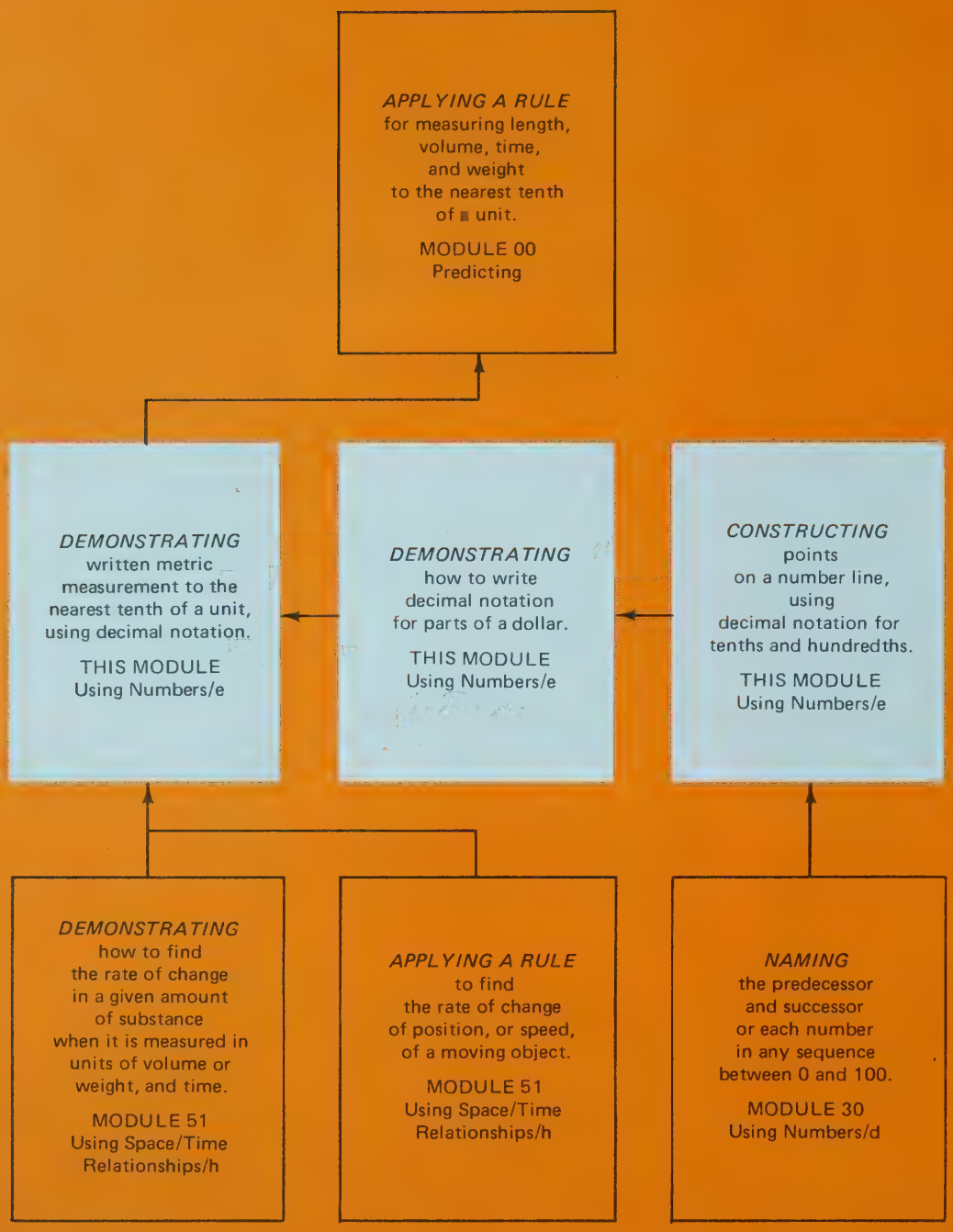
SEQUENCE


APPLYING A RULE
for measuring length, volume, time, and weight to the nearest tenth of a unit.
MODULE 00
Predicting
DEMONSTRATING
written metric measurement to the nearest tenth of a unit, using decimal notation.
THIS MODULE
Using Numbers/e
DEMONSTRATING
how to write decimal notation for parts of a dollar.
THIS MODULE
Using Numbers/e
CONSTRUCTING
points on a number line, using decimal notation for tenths and hundredths.
THIS MODULE
Using Numbers/e
DEMONSTRATING
how to find the rate of change in a given amount of substance when it is measured in units of volume or weight, and time.
MODULE 51
Using Space/Time Relationships/h
APPLYING A RULE
to find the rate of change of position, or speed, of a moving object.
MODULE 51
Using Space/Time Relationships/h
NAMING
the predecessor and successor or each number in any sequence between 0 and 100.
MODULE 30
Using Numbers/d

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II**, is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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RATIONALE

In this module, children are introduced to decimal notation through things familiar to them—money and metersticks. *Activity 1* and *Activity 2* are auto-instructional so individual children or pairs can be working on their own while other modules are being taught. If enough copies of the booklets are available for each pair of children to have one, then they all can work together on the module.

Almost all countries in the world now use the metric system of measurement. To compete economically, the United States will also have to shift to the metric system. As the changeover to the metric system occurs in the United States, it will become increasingly important for children to use the metric system in all their daily activities.

When children use the currency of the United States of America or a meterstick, they use decimal notation. Children who are familiar with the dollar and its divisions, should be able to comprehend and use metric decimal notation after completing the first auto-instructional booklet. This module presents measurements with a meterstick as "money without the $ sign."

The booklet, *Money and Decimals,* is devoted to money. To most children, this booklet will be a review. However, some of the material in *Money and Decimals* is prerequisite for work in *Metersticks and Decimals,* which is devoted to decimal notation and metric measurement. It is advisable that all children complete *Money and Decimals* before turning to *Metersticks and Decimals* because confusion might result when reference is made to work done in *Money and Decimals.*

The numbers on the meterstick mark centimeters. They indicate parts of a meter only if a decimal is added; for example, 23 centimeters = .23 meters. If the children appear to have difficulty seeing the relationship between the figures in the booklet and the corresponding parts of the meterstick, you might have them place a decimal point before each number on the meterstick. If the metersticks being used do not have longer lines to mark each decimeter, extend these lines with a marking pen and label them 1, 2, 3, and so on.

In *Science . . . A Process Approach* measurement to the nearest tenth is sufficient for almost all modules. Although the children do not use decimal notation to hundredths much in later modules, learning hundredths decimal notation will further their recognition of the utility and convenience of decimal notation. They use hundredths decimal notation when they handle money.

Vocabulary

decimal	tenth
decimal point	hundredth
notation (optional)	

INSTRUCTIONAL PROCEDURE

Introduction

Have the children bring in advertisements from newspapers that can be used to review monetary notation. Ask the children to look for advertisements that use decimal notation ($.00) rather than cents notation (00¢). (See Figure 1.) The children could determine which item or items advertised are most expensive. They could also order the items advertised from least to most expensive.

Materials

Advertisements, brought in by the children

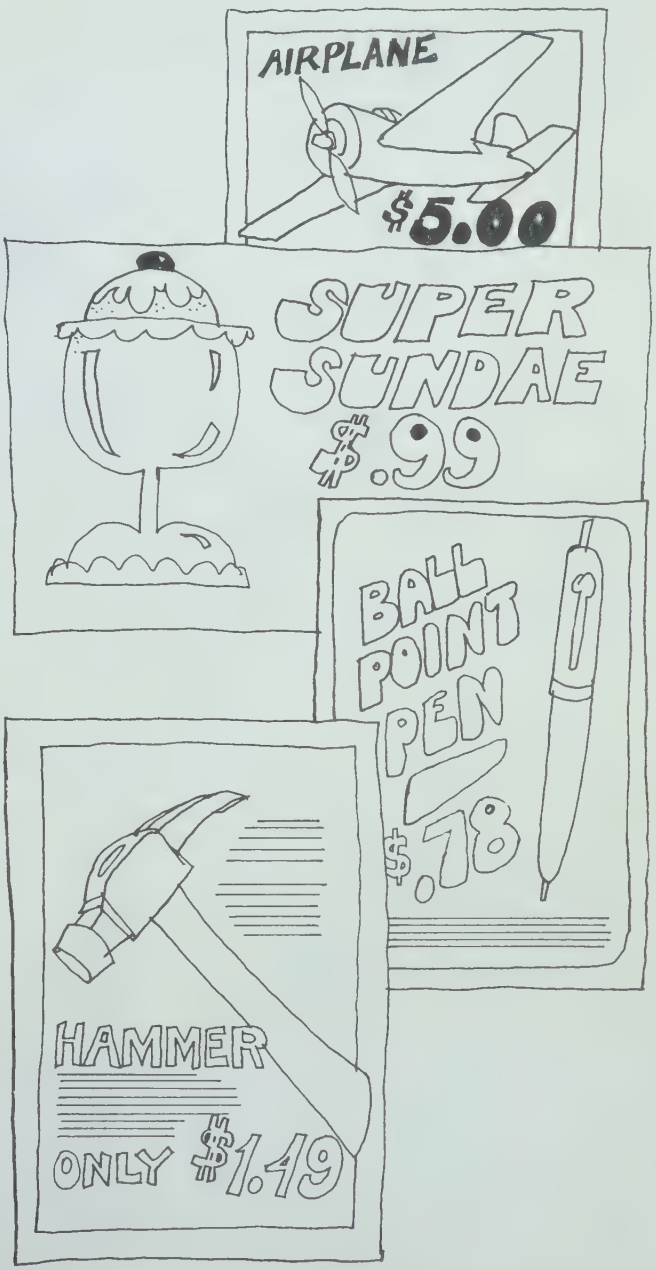

FIGURE 1

Activity 1

Give the child a copy of the booklet *Money and Decimals,* a pencil, and a magic pen. Have the children work on their own without further instruction from you. Explain how a magic pen can be used to verify an answer. Be sure the children know how to use the magic pens.

When all of the children have finished, discuss their answers. Call on several children to write on the chalkboard the notation for amounts of money you name.

Materials

Money and Decimals, 5 spirit masters (*Module 59*)
(Note: Prepare the booklets, *Money and Decimals,* by stapling copies of the spirit masters as shown in Figure 2.)
Pencils, 1 for each child
Magic pens, 16 (*Module 59*)

Activity 2

Show the children a meterstick and ask them how it is used. Most will identify the meterstick and will know how to use it, but few will know how to write measurements using decimal notation.

Give each child a copy of the booklet *Metersticks and Decimals,* a meterstick, a pencil, and a magic pen. As you give them the booklets, tell the children that meterstick measurements and money can be written in much the same way. Also say that the booklet will show them what you mean. Have the children proceed to complete *Metersticks and Decimals* without further instruction.

When all of the children have finished, discuss their answers and any questions they have.

Materials

Metersticks and Decimals, 9 spirit masters (*Module 59*)
(Note: Prepare the booklets, *Metersticks and Decimals,* by stapling copies of the spirit masters as shown in Figure 2.)
Metersticks, 10 (*Module 48*)
Pencils, 1 for each child
Magic pens, 16 (*Module 59*)

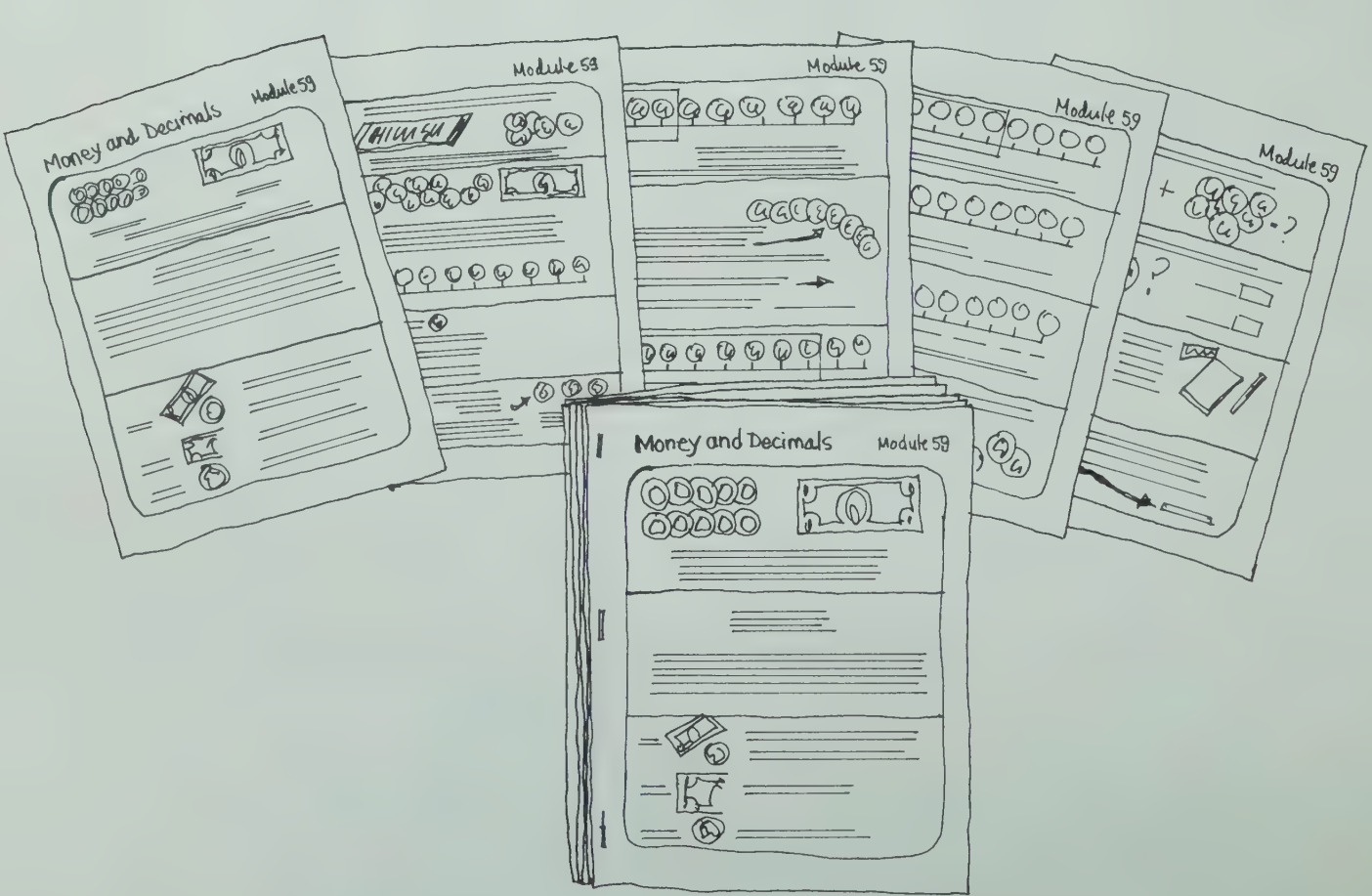

FIGURE 2

Activity 3

On the floor construct several number lines from $^{-}5$ to 5 with divisions to indicate tenths between each whole number. Divide the children into groups, one group for each number line. Give each child a marker, such as a toy car or a cube, and give each group a spinner. (See Figure 3.) To begin the game, each child in turn spins the pointer and puts his marker on the numeral that the needle points to. On subsequent turns, the children move their markers the number of places indicated by the pointer. For instance, if the pointer points to 1.3 the child moves the marker 1.3 places in the positive direction (the direction of the positive numerals). If it points to $^{-}1.3$ (as in Figure 3), the marker should be moved 1.3 places in the negative direction. After the child has moved the correct distance in the correct direction, the marker is left in its new position while other group members take their turns. The game continues until one child reaches either 5 or $^{-}5$.

Materials

Cubes, 1-cm, 1 for each child (*Module 51*)
Toy cars, 8 (*Module 54*)
Spinners, 4 (*Module 59*)

(Note: Divide each spinner into eight equal segments and label the segments 0.5, 1.0, 1.3, 2.0, $^{-}0.5$, $^{-}1.0$, $^{-}1.3$, and $^{-}2.0$.)

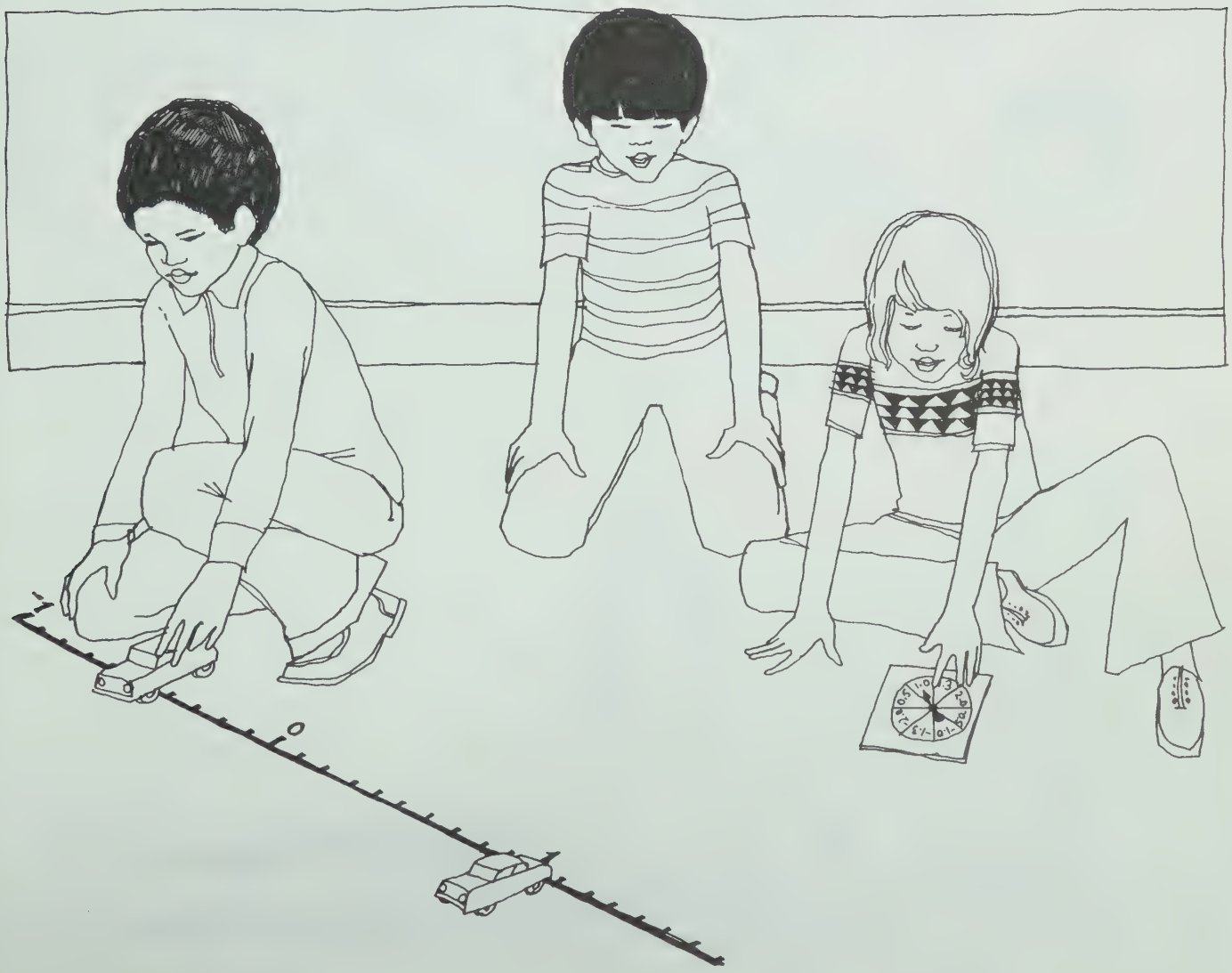

FIGURE 3

Generalizing Experience

Choose any of the following and present them to the children as suggestions for activities.

1. Reserve a location on a bulletin board for "Metric In The News". Have the children report on news articles to the other children and contribute clippings to the board.

2. Reserve a space in the library or learning center for In The News" contribute clippings to the board.

2. Reserve a space in the library or learning center for books on measuring and monetary topics. Encourage the children to borrow the books or to read them on-site and to contribute information gleaned from the titles to group discussions.

3. Offer the children opportunities to describe instances of their use of metric measurements in daily activities. The children should use, with increasing frequency, the metric system rather than the English system.

4. Provide opportunities for the children to measure objects in the room using linear metric units and incorporate measurement into activities.

Materials

News clippings, brought in by children

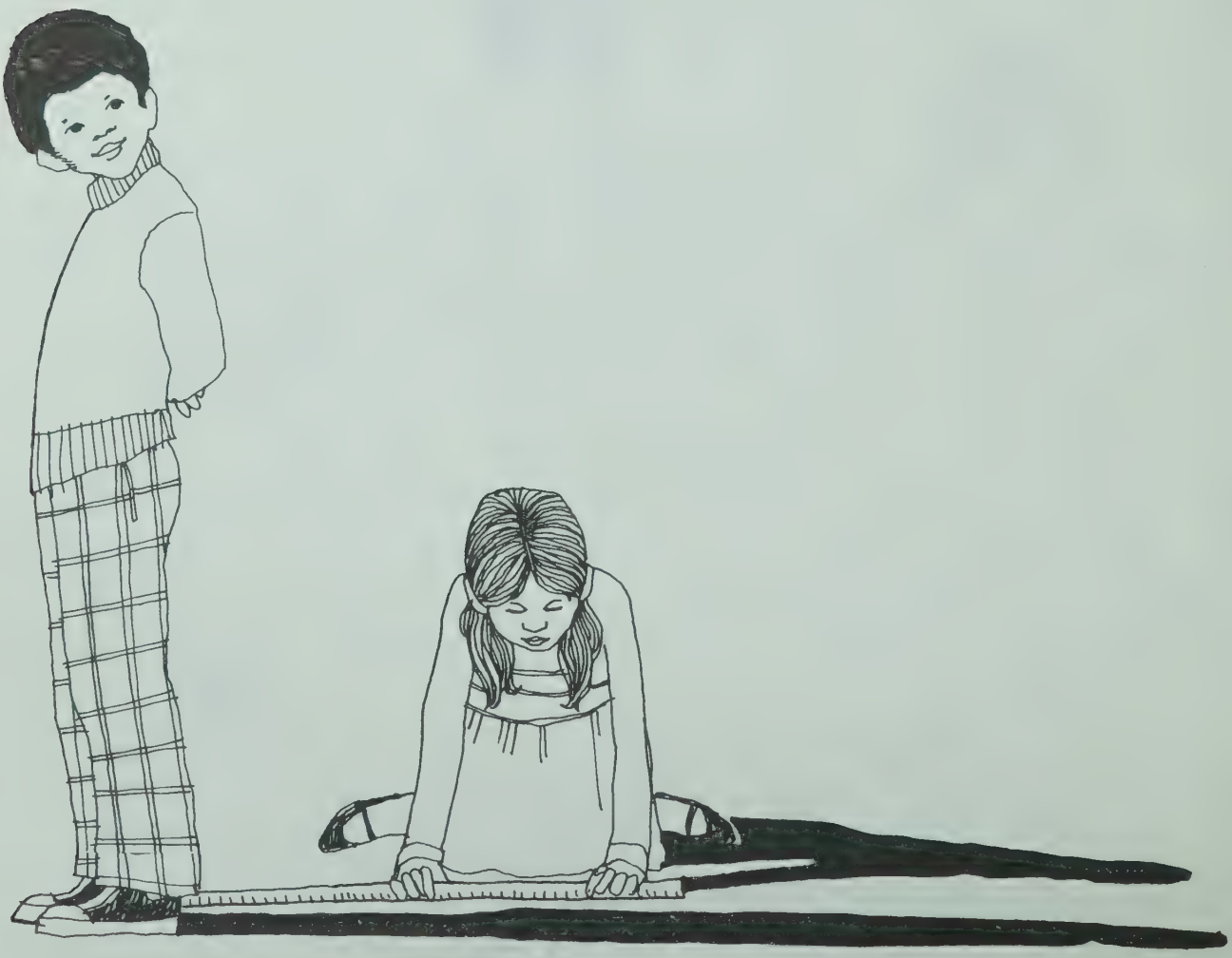

FIGURE 4

APPRAISAL

Present the following activities to evaluate the childrens' abilities to determine decimal notation and lengths using metric measurement.

Have the children measure the length of one another's shadows (see Figure 4) at different times during the day. Children can observe that their own height does not change, while that of their shadow does.

Ask the children to measure the length of their feet or the diameter of coins such as a penny, nickel and dime to the nearest centimeter.

Have a group of children set up a store in the classroom to sell books, games, or toys during free time or recess. Distribute play money to the children so that they can buy these items from the store. Later have other groups of children take charge of the store to sell other items.

Ask the children to measure their books or toys and express the lengths in centimeters and decimal parts of meters.

Materials

Metersticks, 5 (*Module 48*)
Metric rulers, 30 (*Module 47*)
Coins, 3, one penny, one nickel, and one dime
Books, games, or toys, an assortment
Play money, 5 sets

COMPETENCY MEASURE

TASK 1 (Objective 1): Place a pencil, an eraser, a pen, and a ruler in front of the child. Then say, Write how much you think each of these cost—just take a guess! The child should write his guesses using decimal notation. If he uses the symbol "¢" ask him to write the response another way.

TASK 2 (Objective 2): Give the child a pencil and a sheet of paper and say, Draw a line segment and mark eleven points on it spaced as nearly at equal distances apart as possible without measuring. Now, label the left-hand point on your line segment 6.20 and the right-hand point 6.30. Use hundredths to label the other points in order. The child should label the points on the line segment correctly (6.20, 6.21, 6.22, . . . ,6.30).

TASK 3 (Objective 3): Give the child a meterstick and say, Measure the width of the window sill and write down the measurement to the nearest tenth of a meter. The child should make the measurement and write it down in meters to the nearest tenth.

Materials

Pencil, 1
Eraser, 1
Pen, 1
Metric ruler, 1 (*Module 47*)
Paper, 1 sheet for each child
Meterstick, 1 (*Module 48*)

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MODULE
60

Using Space/Time Relationships/i

Relative Position and Motion

OBJECTIVES

At the end of this module the child should be able to

1. *DESCRIBE* positions and appearances of objects relative to himself and to other observers.
2. *DESCRIBE* changes in positions of objects relative to himself and to other observers.

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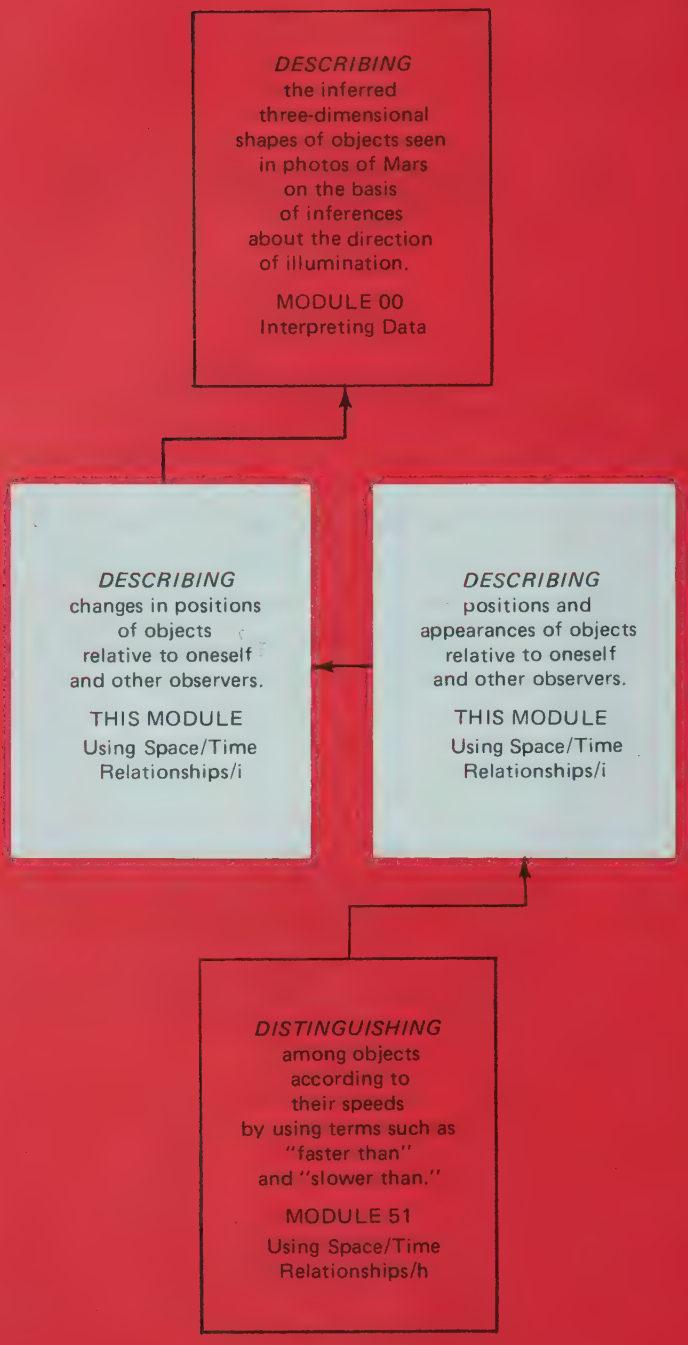
DESCRIBING the inferred three-dimensional shapes of objects seen in photos of Mars on the basis of inferences about the direction of illumination.
MODULE 00 Interpreting Data
DESCRIBING changes in positions of objects relative to oneself and other observers.
THIS MODULE Using Space/Time Relationships/i
DESCRIBING positions and appearances of objects relative to oneself and other observers.
THIS MODULE Using Space/Time Relationships/i
DISTINGUISHING among objects according to their speeds by using terms such as "faster than" and "slower than."
MODULE 51 Using Space/Time Relationships/h

Use of this chart, the instruction booklet, and other elements of **Science . . . A Process Approach II,** is described in the **Program Guide** available on request from Ginn and Company: Lexington, Massachusetts 02173.

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0-663-30463-6

RATIONALE

The purpose of this module is to help the child develop skills in visualizing things as others see them. This should help the child understand that others do not necessarily perceive situations exactly as he does. This attitude is important, and is useful in many fields of endeavor. For example, Copernicus' ability to visualize a rotating earth revolving around the sun led to the overthrow of the Ptolemaic earth-centered concept of the universe, and opened the door to ideas that have led in our time to space probes and moon landings.

Most children realize that the same object or situation looks different to observers in different places. A baseball game, for example, looks different from home plate than it does from left field. At this age, children should be able to make simple but accurate descriptions of what they can see, but they might have difficulty describing what another person can see when viewing the same object or situation from a different location.

Vocabulary

relative

INSTRUCTIONAL PROCEDURE

Introduction

Read the children the following story about Katie.

> Katie's father was going to take her rowing on the pond. She sat in the back of the boat as he went to the bow to untie the rope that held the boat to the dock. Then he suddenly stopped and said, "I'm afraid I forgot the lunch." He climbed out onto the dock and started walking back to the house. He said to Katie, "You stay right where you are. Don't move. I'll be right back."
>
> Katie lay down in the bottom of the boat so she could look up at the white clouds moving across the sky. A little breeze made the waves slap against the side of the boat. Everything was very quiet. Then she heard her father's voice calling from a short distance away, "Katie, come back here! I told you to stay here!"
>
> She sat up suddenly. The boat was about three meters from the dock, floating across the pond, pushed by the breeze. "But, Daddy," Katie said as she paddled back to the dock, "I didn't move at all. I stayed right in the back of the boat where you told me to stay."

Let the children discuss what happened. They will probably agree that both Katie and her father were right. Tell the children that Katie did not move *relative* to the boat but that she did move *relative* to the dock.

Next read the children this second story about Katie.

> Katie and her mother were going on the train to visit her grandmother. They got on the train and found a seat so Katie could look out of the window. She saw a sign outside the window.
>
> Now everyone was waiting for the train to start. Katie's mother went to ask the conductor when they would arrive at Grandmother's city. Katie's mother said, "Stay where you are. I'll be right back." Katie stood up so she could look down the aisle. Suddenly there was a big jerk, and she almost fell down. When she got her balance, she noticed that she could not see the sign outside the window anymore. She walked down the car until she was again next to the sign. Then she realized the train was starting to move. Katie said to herself, "I must wait next to the sign for Mother." Pretty soon she was running. Just then she ran into her mother. "Where are you going, Katie?" asked her mother. "I'm not going anywhere, I'm just trying to stay still," said Katie.

Again let the children discuss what happened. Ask questions such as the following:

Did Katie move or didn't she?

Suppose someone were standing by the sign looking through the train window—would he have seen Katie move?

Did Katie move relative to the sign?
relative to the train?

Activity 1

Have Child *A* stand on one side of the room and Child *B* on the other. Ask both children to watch Child *C* pull a wagon or gym scooter across the front of the room. Ask each of the three children:

Did the wagon move?

In what direction and how far was the wagon from you at first?

In what direction and how far is the wagon from you now?

Did the direction and distance of the wagon change relative to you?

Did the wagon move relative to you?

Children *A* and *B* should answer that the wagon did move relative to them. Child *C* should understand that while the wagon did indeed move, it did not move relative to him, since he was moving with the wagon.

Put a large block (or similar object) in the wagon and repeat this activity and the series of questions with different children. Here are two additional questions you can then ask the class: Did the block move relative to the wagon? Did the block move relative to Child *C*?

Finally, repeat the activity with different children, but this time have a fourth child sit in the wagon and hold the block. Continue to ask questions about relative position and motion. If at any time a child has difficulty deciding whether or not a position has changed relative to an observer, ask him to give the starting and ending directions, as well as the distance of the object from the observer at different times.

Materials

Wagon, 1, large enough for child to ride in, or gym scooter
Large block, 1, or similar object, such as a dictionary

Activity 2

Ask eight children to form a circle about 4 meters in diameter. Ask the children to space themselves so the distances between them around the circle are about equal. While the rest of the children watch, have the children in the circle walk single file around the circle, trying to keep their spacing constant.

After the children have circled several times, have them stop. Then ask the watchers to describe what they saw and what they think the walkers saw. If necessary, ask questions such as these: Did the person in front get closer or farther away? Did the children across the circle appear to be moving? In what direction? Did the children not in the circle seem to be moving? Then let the walkers describe what they saw as they walked, and what they think the watchers saw.

Activity 3

Materials

Wagon, 1
Small toy car or truck, 1 (*Module 54*)

Have a child put a toy car in a wagon as shown in Figure 1, pull the wagon until it is moving fairly rapidly, and then stop it suddenly so that the toy car moves forward. Have the children describe the motion of the toy car relative to the room and relative to the wagon. (Relative to the room: The car moves forward. After the wagon stops, the car continues to move. Relative to the wagon: The car remains in one place. After the wagon stops, the car moves forward inside the wagon.)

Ask the children to imagine that they are driving the toy car and to describe what they would see as the wagon is pulled and then stopped suddenly. (The inside of the wagon would not move relative to the car as the wagon is being pulled. When the wagon is stopped the inside of the wagon would move backwards relative to the car).

FIGURE 1

Generalizing Experiences

Find the location of your school on a globe of the earth. Attach a piece of modeling clay to the globe at that point to represent a person. Put a ball representing the sun about 2 meters away from one side of the globe. Remind the children that the sun rises in the east and sets in the west. Ask them to turn the globe so that the ball would appear to the observer on the globe to rise in the east and set in the west. You may have to remind the children that east on the globe is toward the right and west toward the left as they face the globe. The children should rotate the globe from west to east to simulate sunrise and sunset. (See Figure 2.)

Have the children describe daily experiences and situations in terms of relative positions and motions. For example, the children might describe what they observe on the playground when they are playing on a swing, a see-saw, or a carrousel. The activities of this module might be extended to include an art exercise in which the children draw or paint pictures of an object or person as seen from different directions.

Materials

World globe, 1
Modeling clay, 1 small piece (*Module 52*)
Ball, 1 (*Module 60*)
Drawing paper, 1 sheet for each child (optional)
Pencils, 1 for each child (optional)
Crayons, 1 box for each child (optional)

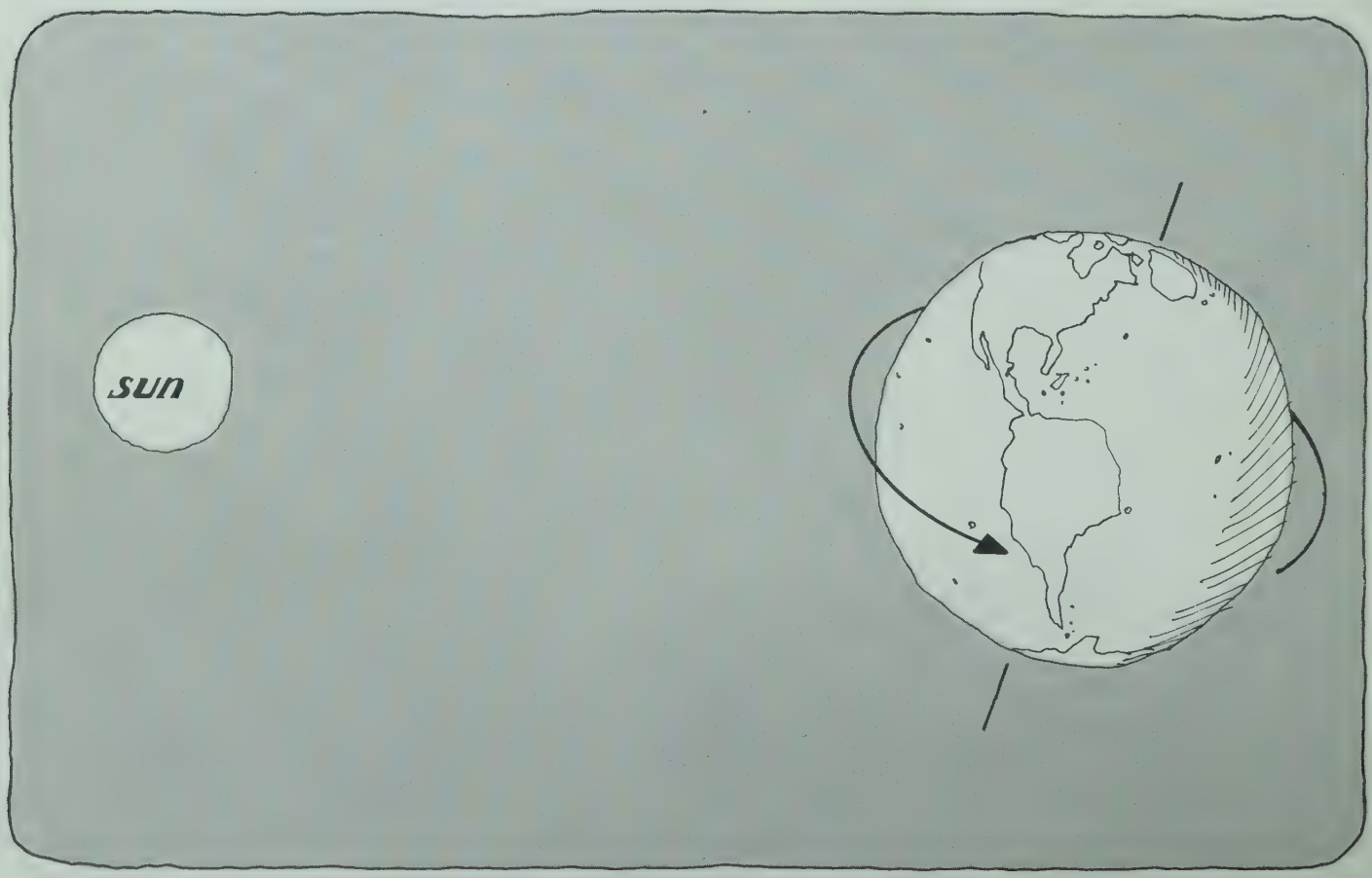

FIGURE 2

APPRAISAL

Give each pair of children a metal mirror. Suggest that they take turns holding the mirror in such a position (see Figure 3) that when they look in the mirror they see the ceiling where the floor should be. Ask the children to describe their observations as they walk. One child of the pair should guide the child holding the mirror. Ask the children what they see as they go through a doorway. (There appears to be a piece of the wall they would need to step over). You or the children might ask other questions: Does the ceiling appear to move? Which way? Does the mirror move relative to you? to the ceiling?

Materials

Mirrors, 15, metal (*Module 60*)

FIGURE 3

COMPETENCY MEASURE

TASK 1 (Objective 1): Sit across a table from the child. Stand a slightly opened book on end in front of the child with the spine of the book facing the child. Say, **Tell me about the position of the book relative to you and also how the book looks to you.** The child should say that the book is directly in front of him and that he can see the spine (or back) of the book, the tops of the pages (if he can), and the front and back covers.

TASK 2 (Objective 1): Say, **Tell me about the position and appearance of the book relative to me.** The child should say that the book is directly in front of you and that you can see the edges of the pages, of the front cover, and of the back cover.

TASK 3 (Objective 2): Show the child a top with compass directions marked on it (Figure 4). Say, **Imagine there is a fly sitting on the North sign looking toward the center of this top. I am going to spin the top and I want you to tell me what the top would look like to the fly.** Spin the top. The child should say that the fly would not see the top move relative to itself.

TASK 4 (Objective 2): Say, **Suppose the fly is looking outward while the top is spinning. What would he see now?** Spin the top. The child should say that the fly would see the objects and people in the room moving past him (from right to left or left to right depending on the direction you spin the top).

Materials

Book, 1, hardbound
Top, 1, with compass directions marked on it (*Module 60*)

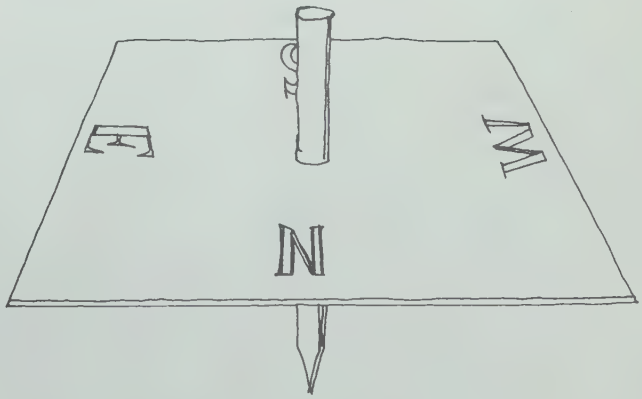

FIGURE 4

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60 Using Space/Time Relationships/i

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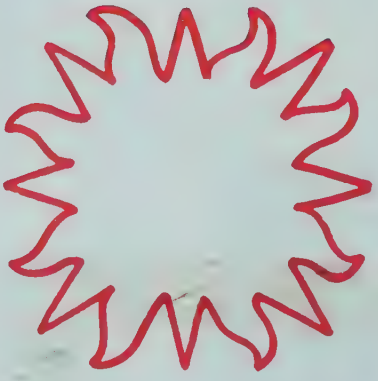

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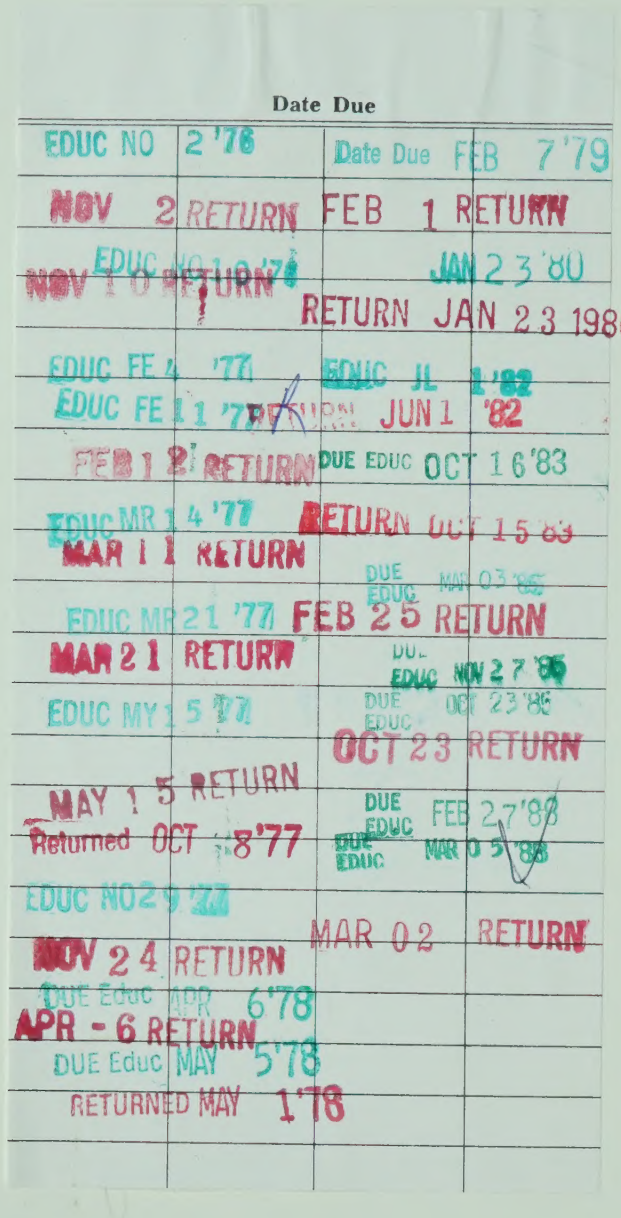

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